

VIII, PART II

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APRIL, 1913

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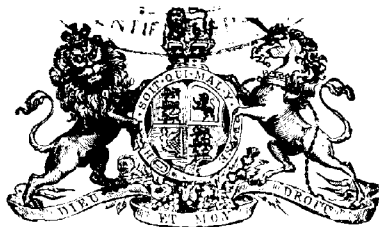
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THE *PSYLLA* DISEASE OF INDIGO IN BEHAR.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

Psylla on indigo in Behar was recorded in Indian Museum News as occurring in July 1907, the indigo crop in Bengal

PLATE I.

Fig. 1.—Eggs laid on the plant; the number is unusually large, a estimate
 2.—The egg. January. Skinned & the Young insects which
 3.—The nymph on hatching
 4.—The plant commencing to curl as the nymphs commence to suck it.
 5, 6, 7.—Nymphs developing; the wing-lobes grow larger.
 8.—The plant as fully curled by a number of developed nymphs, it has
 9.—The winged adult.

10.—Adults on the plants; they do not cause curling and sit openly on the plant.
 11.—A report was prepared and circulated among members of the Behar Planters' Association. In this report, it was stated that *Psylla* was probably indigenous to Behar, was no new insect from elsewhere, and the question of why in 1907 it should be excessively abundant was discussed. Two alternatives were suggested, one that the weather had been unusual and favoured it, the other that the cultivation of Java plant throughout the year had favoured it, as it lived and bred all the year on the indigo sown in September or on the plants left standing in October for another year. It was also pointed out that if the outbreak was due to weather, it would pass off, if due to the altered way of growing indigo it would grow worse. The 1907 outbreak was put down to a combination of both causes and, in the light of subsequent events, probably this was only partly correct, weather conditions having nothing to do with it. (Agricultural Journal of India, Vol. II, p. 384.)

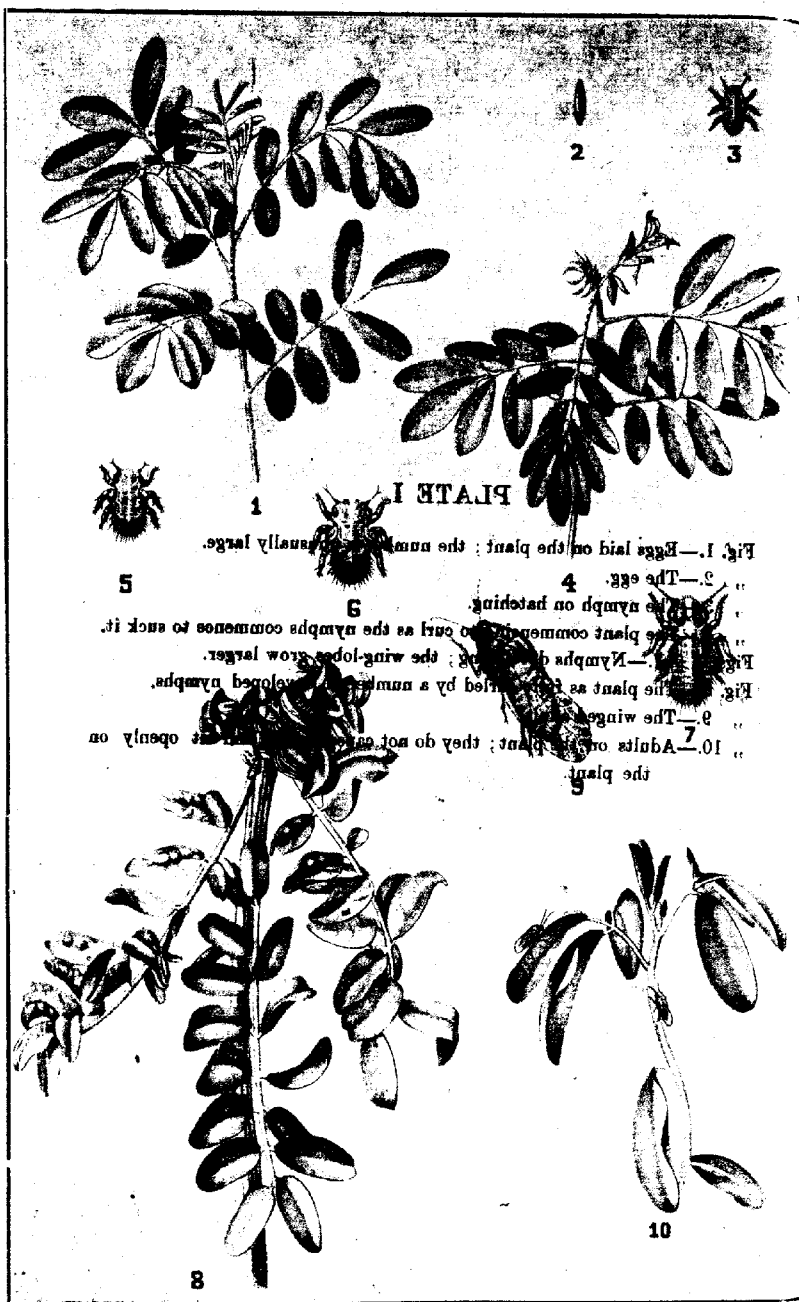


Fig. 1.—Races laid on the plant; the number usually large.

Fig. 2.—The egg.

Fig. 3.—The nymph on hatching.

Fig. 4.—The nymph commencing to cut as the nymph commences to suck it.

Fig. 5.—Nymphs of the winged stage; the wing-lobes now larger.

Fig. 6.—The plant as infested by a number of winged nymphs.

Fig. 7.—The winged nymphs on the plant; they do not cut.

Fig. 8.—Adults on the plant; they do not cut.

Fig. 9.—The plant.

THE *PSYLLA* DISEASE OF INDIGO IN BEHAR.

BY

H. MAXWELL-LEFROY, M.A., F.E.S., F.Z.S.,

Imperial Entomologist.

Psylla on indigo in Bengal was recorded in Indian Museum Notes as occurring in July 1890, the indigo crop in Bengal having been reduced about one-third according to an estimate made by Messrs. Jardine, Skinner & Co. Young insects which were then named *Psylla isitis* were found on affected shoots. It is known also to occur in Madras, specimens having been sent to Pusa in 1905 from South Arcot; and in Cawnpore, where it has been found this year.

In 1907, it was abundant in Behar and a report was prepared and circulated among members of the Behar Planters' Association. In this report, it was stated that *Psylla* was probably indigenous to Behar, was no new insect from elsewhere, and the question of why in 1907 it should be excessively abundant was discussed. Two alternatives were suggested, one that the weather had been unusual and favoured it, the other that the cultivation of Java plant throughout the year had favoured it, as it lived and bred all the year on the indigo sown in September or on the plants left standing in October for another year. It was also pointed out that if the outbreak was due to weather, it would pass off, if due to the altered way of growing indigo it would grow worse. The 1907 outbreak was put down to a combination of both causes and, in the light of subsequent events, probably this was only partly correct, weather conditions having nothing to do with it. (Agricultural Journal of India, Vol. II, p. 384.)

Information was collected in 1907 by the Behar Planters' Association as to the prevalence of *Psylla* on factories and the Managers of many Concerns were good enough to send in information. In 1908, the pest was reported to Pusa from Benipore, Sakri and from Kooria, Bettiah. In 1910, it was reported from Ilmasnuggar, Samastipur and from Nawadah Seeraha. In 1910, it appears not to have been general as information was asked for and only two Concerns reported it. In 1911, it was reported from only a few Concerns, but was doing serious damage, and in November the General Secretary, Behar Planters' Association, wrote to the Inspector-General of Agriculture, referring to "disease" in the koontee crop and estimating the loss at Rs. 15,00,000. This loss was not attributed directly to *Psylla* but partly to *Psylla* and partly to what were believed to be fungoid diseases.

At the present time, indigo is growing in Madras, in the United Provinces and in the Punjab on the old system which prevailed before Java was introduced: in these places, *Psylla* occurs and its parasite; no new parasite has been found, but in these places *Psylla* has not assumed the large proportions it has in Behar, nor is it a serious pest; it occurs there as it did in Behar before Java was introduced, on a small scale and completely kept in check by natural causes. The reason it has remained as a serious pest to Java indigo since 1907 is, I believe, entirely due to the change in the method of growing indigo; all the available evidence supports this view and there is nothing unreasonable in it.

• *Existing Diseases.*—The Java indigo plant at the present time differs markedly from the plant grown in 1905-1906 when Java was first introduced. This difference is shown clearly both in koonties and in moorhun plant kept for seed. Almost everywhere in Behar, there is a very great decrease in the yield of koonties, due to their poor growth and to the loss of leaf. Two distinct sets of conditions are noticeable. In the first the plant grows weakly; some of it dies, the leaf drooping, withering and turning black, the shoots die completely; this occurs in koonties sporadically or in blocks, and affects mostly quite young shoots

on plant that has been cut late. It occurs rarely in moorhun plant. Much more of the plant presents different symptoms; the leaflets become crisp, curl longitudinally towards the mid-rib, turn yellow and fall off; instead of a long growth of green leaves one finds a small cluster of foliage at the tip of the shoot, the leaflets frequently being very small and yellow; eventually these shoots dry up; in many cases fresh green foliage grows at points on the stems, but this does not fully develop.

These two appearances of disease appear to be distinct; they may occur on the same plant; they may occur on koontie or moorhun plant; but, on the whole, there is comparatively little of the black wilting and a very great deal of the yellowing. So far as my observation during three months this year shows, the loss of plant in koonties and the failure of either koonties or moorhun plant to produce seed is almost wholly due to the latter condition which we may, in the absence of a name, call X. The terms Wilt and Charybdis have been used to designate this condition of the plant; "wilt," if used at all, should be reserved for the condition when the leaves become flaccid, turn black and dry up, not for the condition we designate X. The term Charybdis is misleading, as the disease follows *Psylla* in time but not as a consequence.

There is a further definite condition of the plant, which has been produced by the presence on the plant of *Psylla*; in this condition, the leaflets curl irregularly, the tender apical shoot ceases to grow straight but curls into a compact knot with the leaflets; almost always it is only the tip of the plant which is affected; in some cases curled leaves are found a little way from the apex, due to the leaflets only having been affected and the shoot having grown through and formed healthy leaves beyond; this condition is characteristic either of a light attack on the leaves only or of an attack which occurred some time before, from which the plant has recovered. If the *Psylla* remains long on one shoot, growth ceases entirely, the tip dies, the leaves fall off and side shoots come out. In the insectary it has been

possible to kill the terminal shoot with heavy infections of *Psylla*, but this rarely occurs in the field.

At the present time only one definite organism has been found on indigo : this is the insect *Psylla*. It has been supposed that all the above symptoms of disease are connected with *Psylla*, but I am convinced that this is not so. The presence of *Psylla* has no direct connection with any disease symptom except the curling of the tips and leaves, and other causes have to be sought for the more serious effects produced. The reasons that lead me to this belief are :—

(1) Java indigo growing at Cawnpore has *Psylla* but shows no other disease symptom than those mentioned as due to *Psylla*.

(2) Plants grown in the insectary and well infected with *Psylla* do not show symptoms of either of the other diseases.

(3) There is not in the field any correlation between abundance of *Psylla* and large loss of plant from wilt or X. If *Psylla* was connected with either, one would find a correlation between abundance of *Psylla* and large loss of plant from wilt or X.

(4) Plant growing in the field, and showing all forms of disease, if kept free from *Psylla* by spraying, does not show any less increase of X than plant in which *Psylla* is not checked.

(5) Sumatrana indigo is heavily infected with *Psylla* but does not exhibit symptoms characteristic of X.

(6) The localised occurrence of X on individual shoots bears no relation to the relative occurrence on these shoots of *Psylla*.

I have very carefully examined indigo growing at a number of Concerns in Behar during August, September, October and November 1912, and I am convinced that there is no direct connection between the occurrence of *Psylla* and the amount of wilt or of X present. I believe that the very great loss in indigo is due mainly to X ; the occurrence of X does not seem to be correlated with any general characteristic of soil drainage, method of cultivation, treatment of the plant or crop rotation which can be found by observation ; X develops from August onwards in

increasing amount in both koonties and in moorhun plant; it develops just as much in plant infected with *Psylla* as in plant freed from *Psylla* by spraying or in plant in which *Psylla* is almost absent. I have seen no plant in Behar absolutely free of *Psylla*; the Sirsiah plants which have been individually under the very closest observation have developed X quite independently of the relative amount of *Psylla* on them; plant grown at Pusa under different conditions has developed X in all cases; there does not appear to be any connection between the foulness of the land or the cleanness of the land and the occurrence of X, and my belief is that in both wilt and X there is an organism or a definite physiological cause completely independent of *Psylla*. I treat *Psylla* therefore as being the direct cause only of curling of the tips and leaves, with a checking of growth, leading to a decreased weight of cut plant and to a small decrease in the seed yield.

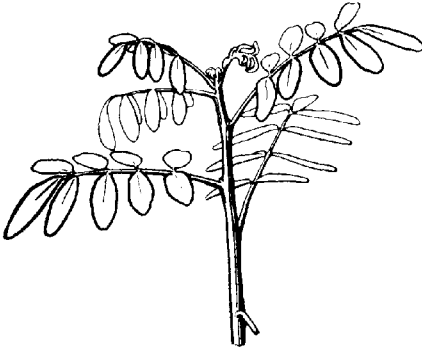
The main factor in the failure of the plant to seed is the great increase of X in the plant from August onwards; *Psylla* checks the growth of the shoot; it does not cause the leaf to turn yellow, or to fall off, nor does it lead to the very extensive death of plant which occurs during October—November. It is clearly a far less important factor than is X, but it is still a factor that cannot be neglected. Fortunately it is a clear definite pest, whose behaviour can be studied and which can be checked without great difficulty. Its position in regard to indigo is quite clear; it behaves exactly like other insect pests and there is no room for doubt as to what it does. It causes certain definite symptoms in the plant, its abundance is due to quite definite known causes and it is possible to put down accurately exactly the part it plays in regard to the cultivation of indigo.

The inquiry this year has shown that we have to look to more than *Psylla*, and while *Psylla* is important, the degeneration of the plant generally, the occurrence of the disease X, the failure of koonties and seed plant are very much more important. If these problems could be settled, if the plant could be got back to the vigour it first showed, indigo

planters would be in a very much better position. The occurrence of the disease X in the experimental plant at Sirsiah has ruined the work that was being done there, and until the problem of this disease is settled, it is unlikely that any progress can be made there. If it had been a question of *Psylla*, it would have been all right, but it is unfortunately not and, if this inquiry has no other result, it has done good by bringing forward the enormous importance of the disease-conditions X and their influence on the indigo crop.

Effect on the Plant.—The effect of *Psylla* on the plant is well known to planters: it differs in the Java and Sumatrana plants owing to their different habit and structure; the Java tip curls into a very compact hard knot owing to the thick stem and the crowded leaves (plate II, fig. 2); the long slender stems of the Sumatrana with their leaves well spread out curl into less compact masses. (Plate II, fig. 4). Curling is caused by the action of one or more nymphs, commencing usually after two days from the time the nymph is put on the plant. In no other way has curling been produced, and though there are other insects on the indigo, the curling is the direct result of the *Psylla* nymph sucking the shoot or leaf. Neither the Aphid nor the Jassid, common on indigo, produce curling. Curling is not permanent; a plant was infested with nymphs (5) on the 17th February and curling appeared on the 22nd. By the 1st March all the nymphs had become adults and the plant was free. It was healthy, the shoot had grown well and there was no sign of curling by the 29th March. Curling is not caused by the adult form: a plant was infested with five adult females that came out on the 22nd February; one escaped; two died on the 26th March, one on the 28th March, one on 29th March. They laid more than 800 eggs none of which hatched (there had been no mating). The plant showed no signs of curling. It is worth noting that whilst in 1907, Sumatrana was more attacked than Java, the reverse is generally the case now: it seems that the insect finds conditions better on the Java plant, mainly, I think, because of the more compact curl produced and so has accu-

PLATE II.



1



2



3



4

4. *J. I.*

Figs. 1 & 2. Java plant, normal, and curled by Psylla.

„ 3 & 4. Sumatrana plant, normal, and curled by Psylla.

tomed itself to that plant and goes less to the Sumatrana ; in addition, the actual damage done to the Sumatrana plant is very much less than to the Java, owing to the different habit of the plant.

Life History of Psylla.—(Plate I). The *Psylla* hatches from eggs laid by the female on the plant and the following are the more important points of the life of the insect :—

Eggs are laid singly, stuck to the plant ; they are laid near the tip of the shoot if there is room, either on the stem itself, or on the leafstalks or the leaflets. Each egg is cylindrical, tapering to each end, one end a little broader than the other ; when first laid they are very pale yellow, almost white ; in two days they become deep black.

The egg bursts at one end and there emerges the young *Psylla* ; when it has got clear of the egg-shell, it walks away. In this form it is called a "Nymph:" it lives for a number of days growing larger ; at intervals it has to moult, casting the complete skin ; this moult allows for growth in size, and also allows the wings to develop. There are five such moults at intervals of 2 to 5 days ; at the last moult the fully grown insect appears, able to fly and also able to reproduce. The male is a little different to the female in appearance, smaller and slightly browner. Until the last moult is completed the insect cannot fly ; it can only crawl ; it spends its time on the tip of the shoot or on the leafstalks or among the curled-up leaves ; it feeds by sucking the juice from the soft plant ; and until it gets winged, it endeavours to spend its whole time in concealment among the leaves where it may obtain food and be sheltered. It is flattened, with long legs, and its general appearance is best seen from the plate ; in the first stage it has no signs of wings, but the wings gradually develop as lobes on the sides and one can tell the stage of development from the size of the insect and of the lobes. In colour it is of a yellowish tint, with the winglobes getting brown ; the larger forms may be greenish.

If eggs are laid by the adult on a plant completely free of *Psylla* and these hatch, curling of the tip will commence after

two days; the nymph alone causes curling and it has only to be on the plant for two days for curling to commence. The nymph is so flat that it can live singly in the tightly-folded leaves of the crumpled top; it is nearly as flat as the common bed bug and has similar habits with regard to the plant that this insect has with regard to man. The fully grown winged form is not flattened, is more active, flies about, and may be seen sitting on the leaves or shoots; it does not cause curling and there is nothing to show if it is on the plant or not, unless it is actually seen. The females can begin to lay eggs in three to four days after they have become winged, and lay eggs during eight to twenty-six days; they may live longer but usually die in about fourteen days after emerging; the males die sooner.

The total life is as follows: the eggs are laid and hatch in from 5 to 10 days; the nymph feeds and develops in the shoot, causing it to crumple, it has five moults, spends over 12 to 20 days and then becomes winged, in four days the males may be dead, the females commence to lay eggs. In the laboratory, adults, both male and female, have lived up to 39 days on indigo. The total period of a generation is from 23 to 33 days; the shorter periods are in the hot weather, the longer in the cold. In the coldest part of the winter there is one generation that occupies at least two months.

This sequence of events is the normal one when there is indigo growing; when there is no indigo, it is uncertain if the adult *Psylla* can live on other plants or can remain alive without food indefinitely. It is certain that it remains alive as an adult, feeding on other plants but not laying eggs on them. That is, the only stage in which it lives over when not on indigo is in the adult condition. This is also the only stage in which it moves about; the nymph, if removed from the plant, can crawl, but ordinarily will not move out of the crumpled leaf unless compelled to.

It is necessary to realise clearly that there are thus two distinct forms of *Psylla*; the egg and nymph forms which are passed on the indigo plant and only there, and which are not

prolonged for more than 20 days in warm weather; and the adult winged form which is independent of indigo except for egg-laying, which flies about, lives on other plants and is not limited to a life of only 20 days.

During this season, it was noticed that some *Psylla* nymphs behaved differently to the rest; instead of remaining in the closely curled top, they migrate down the stem and fix themselves in a colony at one spot; this was observed by Mr. Parnell at Sirsiah; it was then noticed at Pusa and colonies were kept under observation.

When a nymph is parasitised, *i.e.*, contains the parasite grub that is destroying it, it has this habit normally but each nymph is solitary; in the above case of colonies some of the nymphs might be parasitised but not all; and some colonies consisted of unparasitised normal nymphs which developed normally to winged adults. This peculiar habit was noticed only in September-October this year, it may be connected with some condition of the plant or with the very heavy fall of dew that set in this year in the middle of September.

Rate of Increase.—Individual females have been found to lay eggs numbering respectively 274, 314, 572, 208, 710, (31), 828. The normal rate of increase we may take to be somewhere between 200 and 800, say 500; *i.e.*, if there is a fresh generation every month, a pair of *Psylla* would increase as follows:—

1st January	...	...	2 <i>Psyllas</i> lay	500 eggs.
1st February	...	...	200 females „	100,000 „
1st March	...	40,000 „	„ „	20,000,000 „
1st April	...	8,000,000 „	„ „	40,000 millions.

This is assuming 400 out of 500 to live to the adult state and of these 200 to be females that mate. This does not occur probably in Nature and there is not normally this actual rate of increase; but something approaching it might occur if indigo was sown in a fresh place surrounded by other crops and one fertile female flew into it from a distance.

Food Plants.—*Psylla* feeds and increases normally upon cultivated indigo; Prain states that both the present cultivated indigos are introduced plants: there is reason to believe that *Psylla* is an indigenous insect to India, and that it took to growing on indigo when that was cultivated. In that case one would expect that *Psylla* bred upon some wild plant either on indigo (i.e., *Indigofera*) or possibly some plant, not allied to indigo, but containing the substance indican. Prain mentions one species of *Indigofera* as occurring wild in Behar; *Indigofera tinifolia*, a small weed in lawns and pastures.

Trials have been made of some of these to see if *Psylla* will feed or will breed on them. With *Indigofera tinifolia* and *I. (?) tinctoria*, no success was obtained. With *Indigofera oligosperma*, *I. pauciflora* and *I. anil*, the nymphs would feed and develop; they are not wild species in Behar however.

These points are important in view of the occurrence of *Psylla* on new lands; it is almost certain that *Psylla* has a wild food-plant in Bengal; this plant may be rare in Tirhoot; we have not found it though we know of two plants other than indigo on which the *Psylla* nymphs will develop; whether we find it or not is immaterial, as *Psylla* may have now entirely forsaken it and adapted itself to cultivated indigo.

It is necessary also to emphasise the fact that in this question of food-plants I am considering those on which the insect multiplies, that is, on which the adult lays eggs and on which nymphs come to maturity; the food-plants of the adult are probably wider and not restricted in this manner. It is thought that *Psylla* reappears mysteriously after floods and also is found unaccountably on lands sown for the first time with indigo, for instance, on clean lands far from cultivated indigo. We know of no stage in which the insect can wait except the adult, we know of no limit to the distance it might be blown, be carried by birds, men or carts, and we have no reason to doubt that female *Psyllas* might in flood go to the tops of trees, and descend again to lay eggs upon indigo after two or more months. When one *Psylla* can produce 600 curled

tops, it can be seen that not many are required to make a visible effect.

Any one interested in this point must remember that it is the winged *Psylla* that is to be looked for off indigo and not curled leaves produced by nymphs.

The distance travelled by winged *Psylla* is not known. Indigo sown in a field in Pusa in November was infected early in February ; there had been no indigo cultivated in Pusa for over 18 months and the nearest was not less than a mile away. It probably took days or weeks to travel this distance.

Psylla occurs everywhere in Behar, I have sought in vain for any indigo completely free, even in fields situated as much as seven miles from any other indigo. On new land never before in indigo and miles from any cultivation of indigo, *Psylla* appears the first season.

Attempts have been made to find the plant on which the winged *Psylla* lives over the winter if there is no indigo or on which it lived before Java was cultivated. It must be remembered that *Psylla* will feed on various indigos, though not on the commonest wild indigo ; and trials have been made with a long series of common plants to see how long adult *Psylla* will live on them. In captivity, *Psylla* will live for forty days on indigo ; on no plant except the above has it lived longer than four days. It is impossible to test all the plants of Behar in a short time ; we have not hit upon its food-plant as yet, but it clearly has one, unless it finds sufficient indigo growing in odd corners or finds sufficient *Tephrosia purpurea*.

Psylla and Sumatrana Plant.—Prior to 1905-1906 or thereabouts, Sumatrana was the indigo grown ; it was in the land from March to October ; from November to March the *Psylla* was in the fields in the winged adult form waiting through the winter. I make this statement deliberately on the evidence available as to its habits, not because I have ever personally seen it. I believe that if indigo was again grown on the old system the former state of things would return and *Psylla* would cause only minor damage, but I do not think that that state of affairs would

be restored at once. This means that seed cultivation could not be done in Behar and that under no circumstances should indigo be grown from November to March.

How Psylla spends the year.—Reviewing the behaviour of the pest through the year, we may briefly state that it behaves as follows : in December-January there are usually winged adults with some nymphs waiting in the young Java or in plants standing over for another year : these breed in March or earlier, this probably varying with the character of the season. From March onwards, the breeding appears to be slow, either because the climatic conditions are unsuitable or because there are checks at work then which later become less active. In June-July the crop is cut ; cutting occupies from four to six weeks ; and there are two ways in which this period is got through ; where a field is not completely cut or there is standing indigo alongside, those *Psyllas* that can, go over to these plants ; a number live over on the stumps until these sprout ; where there is no indigo near, and the stumps are covered, all but the winged ones perish and those winged ones, that can reach other indigo, do so by flying ; if not they live over on other plants till the indigo grows again. When it grows again, the winged ones enter it and start egg-laying. Breeding then goes on very rapidly until November when the cold weather checks its rapidity, and the adults, as they become adults, tend to live over without breeding until February.

From the point of view of checking the pest, we must direct our attention to this period when the indigo is cut. I return to this point below.

Enemies.—*Psylla* has, like other insects, enemies which feed upon it or otherwise destroy it. We know definitely of three Ladybird Beetles (*Coccinella septempunctata*, *Chilomenes sexmaculata*, *Brumus suturalis*), a Chrysopa (*Chrysopa alcestes*) and a Syrphus (*Pelecocera* sp.) which do so and there is a Mantis (*Hierodula westwoodi*) and a Spider. These actually eat the *Psylla* nymphs : they also eat other insects, and the question whether they attack *Psylla* or not depends probably largely on the presence or absence of other insects they feed upon. There

is, for instance, an Aphis on indigo which they also eat and there are other insects on other crops which they feed on. There was, for instance, no Aphis on any of our indigo before 5th May. On 1st July Aphides had already appeared. After that Aphides have gone on increasing and most probably diverting the enemies from *Psylla*.

There is also a parasite, that is, an insect which lays an egg in a *Psylla* nymph, this egg developing inside the *Psylla* nymph and destroying it. This insect does not attack insects so varied as the others do and is a more direct check upon *Psylla*. It destroys only the nymphs: it lays an egg in the nymph: this hatches inside to a grub, which absorbs the nutritive matter in the grub and slowly kills it; before it perishes, the nymph comes out of the curled top, fixes itself on the stem and dies, turning brown and forming a case for the parasite grub to pupate in.

The presence or absence of these insects very largely determines whether *Psylla* is abundant or not; and if one considers the rate of increase of *Psylla*, its dependence upon the indigo plant, the action on it of climate, the effect on it of some six or more different enemies, one can see that the problem of why *Psylla* is at one season or another abundant or scarce is a complex one. In nature, as a rule, checks (*i.e.*, enemies and parasites) tend to balance the natural increase of an insect and to keep it down to a level, which varies a little but never admits of an enormous increase of the insect; this balance is delicate and the change in the method of cultivation of indigo has upset it; the result is too much *Psylla* and it is a question how long a period will elapse before the balance again adjusts itself, before the enemies adjust themselves to new conditions and are able to again cope with the increase of *Psylla*. I have put it very crudely but I believe approximately correctly.

What happens at Cutting.—I now return to the important moment when the crop is cut; if this is properly done, the *Psylla* is suddenly checked; nearly all the nymphs are carried off with the plant; mainly winged adults are left which sit on the stumps

and there is, for some time, no young *Psylla* for the Ladybirds and other enemies to feed on. These enemies go to other crops, e.g., *makai*, and feed on other insects. When the crop grows, *Psylla* is there, the enemies are not there and the *Psylla* for some time breeds unchecked. This brings about (1) the absence of *Psylla* on koonties at first, (2) the subsequent enormous increase of *Psylla* during July and August unchecked by enemies, which only again get a hold of it by September.

The only enemy that is probably limited to *Psylla* is the parasite; it probably waits and attacks *Psylla* again soon; it is, however, not so important a check as the *Syrphus* and appears not to be able normally to check *Psylla*.

It is now known that the nymphs can live on the stumps. The grown-up nymphs (4th and 5th stages) have also been found able to crawl over a distance of more than 5 feet. Very few, however, fall off the green plant when it is cut; almost all are removed to the vats, with their parasites in them if they have any. It is certain that all these nymphs, which fall off on fields, do not die, if the plants are not properly cut to the ground: if any shoots are left uncut, some certainly live on these and others live on the cut stumps if these are left exposed. But without food all die within two days.

Conditions in 1912.—In the past we have only had general observations to rely on, going back to 1907 and mainly made at Pusa and Sirsiah. From the beginning of August 1912 to the middle of November, the crop was very closely studied and an endeavour made to grasp the problem. A number of Concerns were visited, some at regular intervals to watch the progress of the outbreak. Also a number of Concerns sent in "curly tops" containing *Psylla* from which we bred any parasites that were in the nymphs.

On the whole, there was much more *Psylla* during August than during September; in almost every case the attack of *Psylla* was worst in July-August but decreased to some extent during September. This recovery was far more marked, for instance, in Motipur, Tatareeah and the neighbourhood than in

Dholi, Mia Chapra and Hursingpur. At the same time this difference was not widespread: Seeraha in September was so bad as to benefit from spraying; Dholi made a recovery during the beginning of October. On the whole, the amount of *Psylla* lessened as the monsoon wore on to its close and I attribute this partly to the increase of parasite but, far more, to the increase in the amount of insects that fed on *Psylla* during September, due, I believe, to the ripening of the *makai* crop. The *makai* had Aphides on which these enemies fed, and when the first indigo cutting was made, these enemies seem to have gone to the *makai*, to return later to the indigo. I attach less weight to the parasite now as in no case was it sufficiently abundant to dominate the *Psylla*.

I attach great importance to the value of checking the *Psylla* early; if we could prevent the great increase which takes place while the *makai* is growing, we could probably keep *Psylla* within limits. The varying conditions of Behar amply account for the variation in the amount of *Psylla* from place to place and if we could have traced all the enemies of *Psylla* through the season, we should be able to see why *Psylla* was less checked in one Concern than in its neighbour.

The Managers of a number of Concerns were good enough to send in information and "curly tops"; I was also able to visit a number of Concerns and to obtain the views of Managers on the disease. The information obtained and the conclusions arrived at are embodied in this report and there would be no useful purpose in discussing this in detail. It is clear that the conditions of *Psylla* and its occurrence are not uniform over a whole district and that they vary from one Concern to another; it will pay every Manager to watch the occurrence of *Psylla* on his lands, and I believe it would pay him to make certain that he had parasite present directly he got evidence of an attack beginning in the koonties in July; this is best done by sending 100 "curly tops" to Pusa and if no parasite is found getting it through Pusa.

The Plant.—In my previous note, I stated that a strong plant was less affected by *Psylla*. I am inclined to attach less weight to that now as I have seen very healthy vigorous plant suffering heavily from slight infestation of *Psylla*. The plant at Sirsiah manured with superphosphate was bigger, robuster and more vigorous; yet we were unable to detect by observation any marked difference in the number of curled heads in the plots. So also at Pusa where there was plant of different ages, some cut, some uncut, some well cultivated, some badly cultivated. Where koonties and moorhun plant stood side by side, the amount of *Psylla* in the koonties was much greater than in the moorhun plant, due to the winged adults migrating; they evidently prefer the low plants, possibly as being more sheltered.

Summary.—To sum up, I regard the present outbreak as the natural consequence of that of 1907; the change of cultivation has upset conditions; *Psylla* is unduly abundant and may remain so for some time; the difference in the amount of *Psylla* at different places is quite understandable; and we have to concentrate our attention on three points: can we restore the previous condition; can we do anything to directly check the present outbreak; can we find any remedy capable of immediate application.

Preventives.—In regard to preventives for the present attack. I would strongly urge that every Planter does what he can to carry out thoroughly four things:

- (1). To cut every plant level with the ground if possible, but if a stump must be left, to leave no green leaf or shoots.
- (2). To cut most carefully every plant, never leaving even one odd uncut one.
- (3). To cut over as big a block of lands at once as possible.
- (4). If possible to plough and hanger the crop after cutting.

I look on these as the most important things and I recognise the difficulties there are, particularly in the third. But if every Planter did what he could in these things, there would be less *Psylla*, and every man who does them will individually reduce the *Psylla* on his own lands. It is definitely known that indigo is

infested quite early ; a small plot was sown in the second week of May 1912 in Pusa and was well infested with nymphs and had curled heads before July 3rd. So it may be also after cutting ; a plot was cut on 12th July, every scrap of green being removed ; it was re-infested and eggs laid by 28th July and curled heads were to be seen by the 31st July. This plot was perhaps 50 yards from another. In the fields of indigo that had been cut and had sprouted, eggs were found on plants that were surrounding odd plants left uncut ; these plants were infested and the *Psylla* adults had clearly moved over. In such cases infestation of koontie plants will be much more rapid than if all plants had been very thoroughly cut.

If when 20 bighas of plant are to be cut, this can be done in a compact block of lands, not in that block omitting any plant at all, those lands will improve. I know it cannot always be done, but I think there would be much less *Psylla* if Planters kept it in mind and did the best they could.

The Future.—It is certain that *Psylla* will remain a pest so long as Java is grown on the present system ; I see no likelihood of things altering, and so long as there is indigo in the land all the winter and the first cutting is made in June, there must inevitably be an outbreak of *Psylla* in July-August. It is necessary to remember that *Psylla* does not do the greatest damage, and I would be inclined to consider the treatment of *Psylla* in connection with that of the disease X. At present both do their work in the koonties ; it would seem possible to avoid having koonties at all and to plough all the Java crop after the first cutting. In many cases koonties have hardly been worth keeping ; and if the ploughing out of koonties were to affect the amount of *Psylla* and also of X, the loss of the second cutting would be worth while.

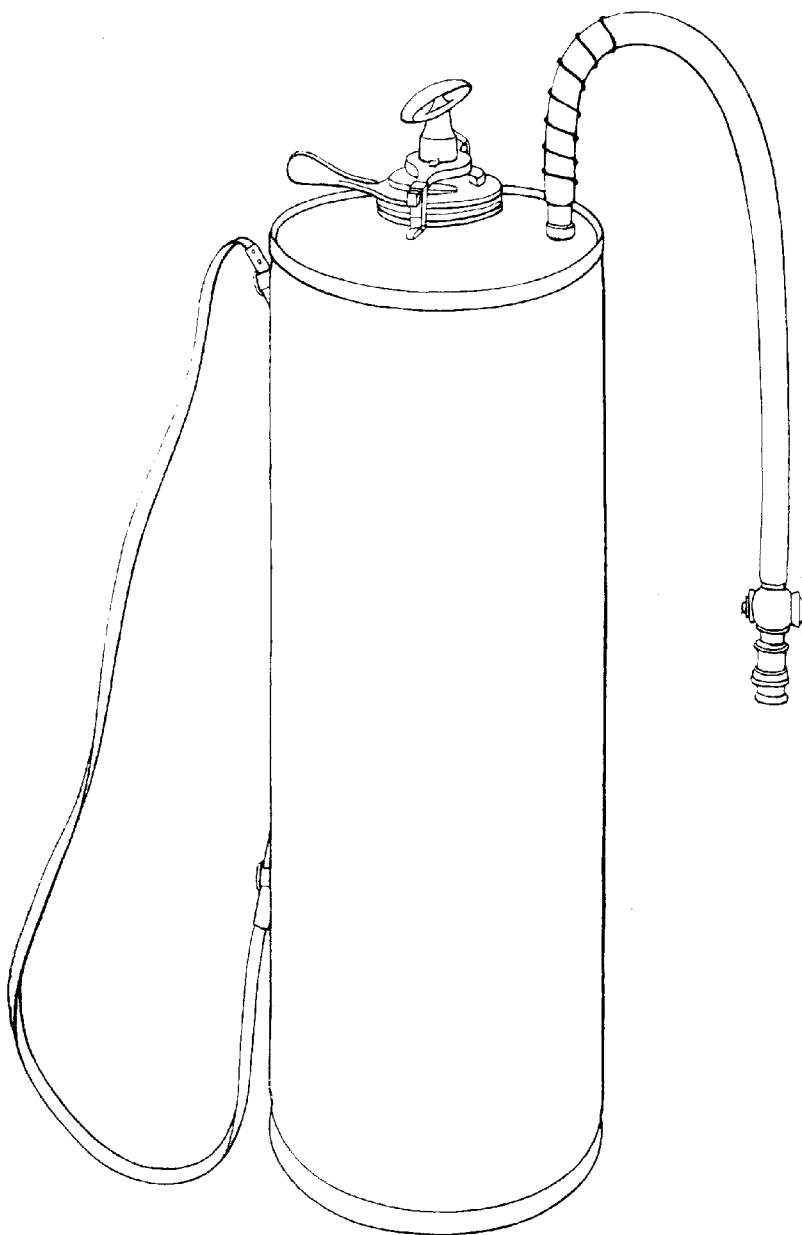
The only alternative I can see is to sow as much Java as possible in February, cut it as early as possible and to carry out the cutting in the way indicated above.

It is impossible to lay down a course of action for Concerns scattered over Behar ; what suits Darbhanga does not suit

Champaran; but it would be advisable for Planters to try to secure two things: (1) a break if possible some time in the year when there shall be no Java in the land, this being in the winter if possible, (2) to make it as difficult as possible for the *Psylla* to live in the fields when the plant is cut.

Two alternative systems have been suggested; one is to sow Java in August, get a seed crop in February and a moorhun cutting in June; then plough. The other is to sow only in February, get two cuttings and keep only the best plant for seed. The latter is, where possible, probably the best as it fits in with the Sumatrana plant cultivation and leaves the land free entirely from indigo in the cold weather. It has been suggested that it may be possible to grow healthy indigo by sowing it with other crops, *e.g.*, wheat, linseed or mustard. So far as I have seen, this practice has not affected the amount of either *Psylla* or X except in one case; some of the most healthy individual plants I have seen were in cane; they were volunteer plants, not having been sown, and were scattered through the cane. If one such plant had got *Psylla*, it had it badly, but the greater number escaped, presumably because the *Psylla* never found it. It is, however, impossible to grow indigo in this way.

Direct Remedies.—A number of experiments have been made with remedies and it is unnecessary to go into detail regarding most of them. We have tried a number of methods of directly attacking the insects; shaking the plants vigorously fails to dislodge them; they are not attracted by light; passing a sticky rope or cloth through the crop fails to do more than capture a few winged adults. A mechanical method of cutting off the tips of the plants in July has not yielded any good result. I still believe that good results will follow the cutting of infested tips if this is properly done; but it is essential that this shall be done by hand, not by a machine, that all “kookragia” heads (curly tops) shall be cut, that they shall be placed at once in bags or baskets and either placed in boxes covered with fine wire gauze or removed to a place where they can be spread out in a layer and covered with cloth. Once a day the



A J. L.

Auto-sprayer ready for use.

cloth is lifted, the parasites that emerge allowed to fly away and the cloth replaced. It is a mistake to cut the tops and either leave them in the field or burn them with the parasites in ; what is required is to place them so that the *Psylla* nymphs cannot get to the plant but to let all parasites emerge which they will do within ten days. As I have had no opportunity of giving this method a proper trial I cannot recommend it, but I think it is worth giving a trial on a small isolated block of plant.

In my previous note, I suggested spraying as a method of directly checking *Psylla* on plant kept for seed. This method has been tested and has given good results. We have sprayed koonties at Dholi, Pusa, Begu Sarai, Sadowah, Sonbarsa and Seeraha : in all we have used soap solution and we have found that the compressed air type of sprayer is the simplest for field spraying and the best adapted to the physique of the Behar coolie.

Soap.—We have tested a series of soaps supplied by firms in India, taking into account :—

- (a) wetting power on curly tops ;
- (b) killing power on *Psylla* ;
- (c) amount of water in the soap ;
- (d) cost.

We have also tested these with insecticides added and, without going into detail, the best solution we have found which will wet indigo, penetrate the curly tops, kill *Psylla* nymphs and adults, is the Oline soap made by the North-West Soap Co., at Rs. 21 per cwt. or as. 3 per lb. This is used at a strength of 1 lb. to 12½ gallons of water.

The Imperial Agricultural Chemist assisted by determining the surface tensions of soap solutions as compared with water and with emulsions of oil and of creosote. The soap solution had a far lower surface tension than water and the addition to it of oil or creosote in emulsion raised the surface tension. As it is important to have a low surface tension, these results confirmed the actual tests of various liquids on the plant.

Soaps differ very much in water content; we found by drying over calcium chloride, the following losses of weight in soap :—

No.	Days dried.	Loss of weight per cent.
1	31	4
2	{ 11	{ 44
3	{ 31	{ 50
4	16	8.6
5	12	55
	9	18

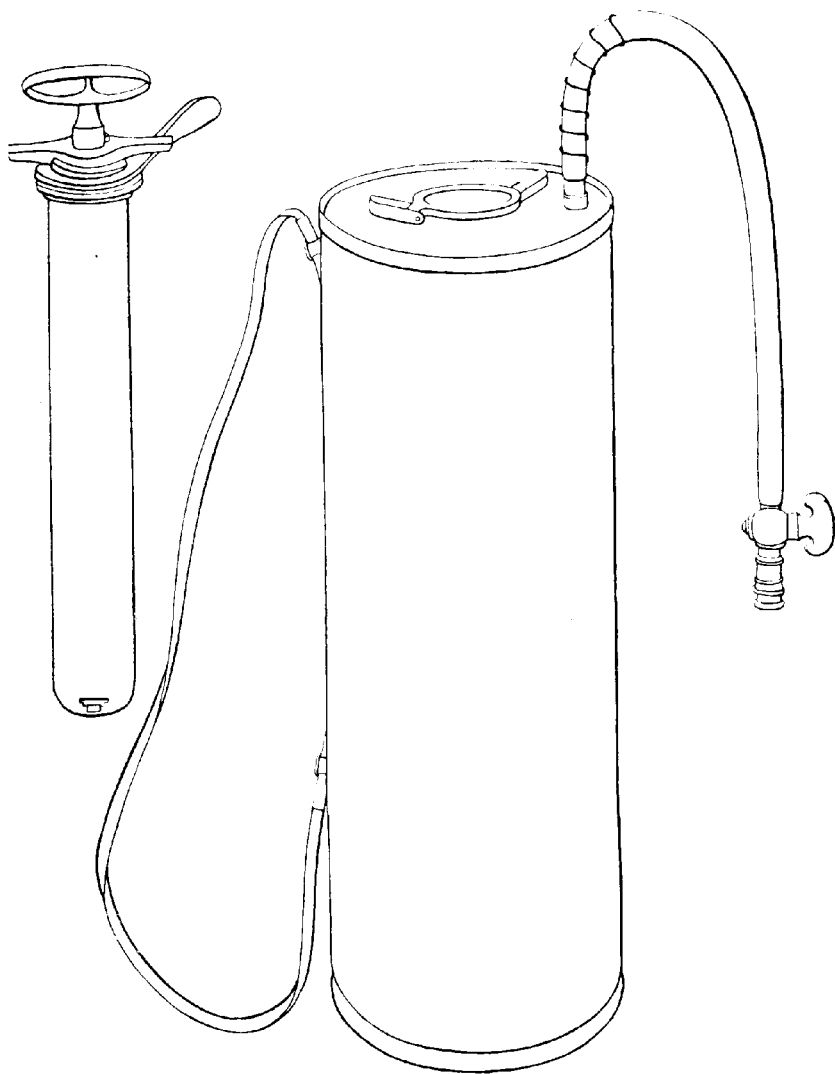
Soap No. 1 costing as. 3 per lb. is cheaper to buy than No. 2 costing as. 2 per lb., as half of the latter was water. We believe we have in Oline bar soap the best available soap for this particular purpose and we have used it exclusively.

Sprayers.—We have tested every kind of sprayer available; we made a cart sprayer doing a strip 15 feet wide automatically; we have used barrel sprayers, knapsack sprayers, bucket sprayers. All can be used, but for spraying koonties with ordinary coolies, we believe that the Auto-sprayer does the best work. Detailed results are given below of the spraying of 110 bighas of indigo.

The Auto-sprayer (Plates III, IV) is a simple cylinder containing an air-pump; it is first partly filled with the liquid; it is then closed, and air pumped into it till there is a good pressure; the coolie then takes it, walks along the indigo with the nozzle open, the compressed air making a good spray; all the coolie has to do is to hold the machine and direct the spray to the plant. For coolies of low physique this machine is the best; we used the Auto-sprayer costing Rs. 30 in Calcutta (Smith, Stanistreet & Co.), because it was available; other makes using the same principle are made and are probably equally good.

3. *Time to Spray.*—No spray found has been effective in killing the eggs; it is therefore necessary to spray twice, with ten days between the two sprayings. Assuming the first spraying to kill all the nymphs and adults, the eggs hatch and

PLATE IV.



1. *J. I.* Auto-sprayer with the air-pump removed and ready for charging with liquid.

become nymphs which will be killed as nymphs or adults by the second spraying; if ten days elapse all the eggs that survived the first spraying must have hatched, but none will have been able to become adult and lay eggs. But care must be taken that each block really is sprayed again ten days after the first.

Our spraying was of necessity done in September-October. I believe it will be best to have one spraying in the kooties in July-August, whenever the attack is seen to be commencing and another, if required, in September or October.

Cost of Spraying.—Statements are attached showing the actual cost of spraying areas varying from 4 bighas to 48 bighas. The cost varies from Re. 1 to Rs. 2 per bigha for each spraying depending on the area, the height of the crop, the distance from the factory and the expertness of the men. The work was done in each case by three coolies from Pusa with three Auto-sprayers and with usually six coolies supplied by the factory, of whom three relieved the men working the machines and three brought water, boiled soap solution, etc. The solution was made by dissolving each 3 lb. bar of soap in 3 gallons of water and then diluting to 35 gallons.

SPRAYING INDIGO.

Sadhowah : *First Spraying.*

Area. Bighas. Kuttas.	Amount of Soap solution.	Coolies.	Cost of labour. Rs. A. P.
0 7	35 gals.	... { 3 @ 2 as. 1½ @ 3 "	0 6 0 0 4 6
2 5	175 "	... { 6 @ 2 " 3 @ 3 "	0 12 0 0 9 0
2 5	175 "	... { 6 @ 2 " 3 @ 3 "	0 12 0 0 9 0
1 8	144 "	... { 6 @ 2 " 3 @ 3 "	0 12 0 0 9 0
6 5	529 gals.	... 31½	4 9 6
Total cost : Labour			Rs. A. P. ... 4 9 6
Soap			... 8 7 0
			13 0 6

Second Spraying.

Area. Bighas, Kuttas.	Amount of Soap solution.	Coolies.	Cost of labour.
			Rs. A. P.
1 15	175 gals.	... { 6 @ 2 as. 3 @ 3 "	0 12 0 0 9 0
4 5	252 "	... { 6 @ 2 " 3 @ 3 "	0 12 0 0 9 0
0 5	35 "	... { 3 @ 2 " 1½ @ 3 "	0 6 0 0 4 6
<hr/> 6 5	<hr/> 462 gals.	<hr/> ... 22½	<hr/> 3 4 6

	Rs. A. P.
Total cost : Labour ...	3 4 6
Soap ...	6 11 0
	<hr/> 9 15 6

SONBARSA

Area.	Amount of soap solution.	Coolies.	Cost of labour.
			Rs. A. P.
0 15	72 gals.	... { 1½ @ 2 as. 1½ @ 3 "	0 3 0 0 4 6
2 5	180 "	... { 6 @ 2 " 3 @ 3 "	0 12 0 0 9 0
0 15	72 "	... { 1½ @ 2 " 1½ @ 3 "	0 3 0 0 4 6
<hr/> 3 15	<hr/> 324 "	<hr/> 15	<hr/> 2 4 0

	Rs. A. P.
Total cost : Labour ...	2 4 0
Soap ...	5 1 0
	<hr/> 7 5 0

BEGU SERAI FACTORY.

Area.	Amount of soap solution.	Coolies.	Cost of labour. Rs. A. P.
3 bighas	91 gals.	... { 3 @ 5 as. 3 @ 1½ "	0 15 0 0 4 6
4 "	130 "	... { 3 @ 5 " 4 @ 1½ "	0 15 0 0 6 0
4 "	130 "	...	1 5 0
3 "	130 "	...	1 5 0
3 "	130 "	...	1 5 0
3 "	156 "	...	1 5 0
20 "	767 "	...	7 12 6
			Rs. A. P.
(16½ acres.)			Total cost : Labour ... 7 12 6
			Soap ... 12 3 2
			19 15 8
<i>Second Time :—</i>			Rs. A. P.
20 bighas	... 1,015 gallons	Labour ...	7 12 6
			Rs. A. P.
			Total cost : Labour ... 7 12 6
			Soap ... 16 5 0
			24 1 6
<i>First Time :—</i>			Rs. A. P.
48 bighas	... 3,276 gallons	Labour ...	24 2 0
			Rs. A. P.
			Total cost : Labour ... 24 2 0
			Soap ... 51 3 0
			75 5 0

SEERAHA.

Area.	Amount of soap solution.	Coolies.	Cost of labour. Rs. A. P.
5½ bighas	... 55 lbs soap :	Labour ...	5 7 0
			Rs. A. P.
			Total cost : Labour ... 5 7 0
			Soap ... 10 5 0
			15 12 0

Effect of Spraying.—The opinions of the managers of three Concerns are as follows :—

Begu Serai.

“Your man is returning as he has finished the first spraying. I consider it has been most successful. About three-quarters of the plant seems to have recovered. The curly tops are opening out and new leaves are forming.”

... ..

*Sadowah Factory,
Sewan, Sarun.*

... ..

“The koonties (Java) kept for seed look A 1 now after being treated with the soap solution which has been done twice.”

... ..

*Seeraha,
Champarun.*

... ..

“The first plot I sprayed here does not seem to have benefited much. This was only a very small plot from which I cut moorhan and kept *all* the koonties. It was badly gone with *Psylla* before the spraying was started. This bit is only a cuttah or two. The rest about 5 bighas in which moorhan was cut, and koonties thinned out, leaving plants about a yard apart or less, has made a very marked improvement after spraying. At first nearly all the plants had curly tops, but now this has disappeared to a great extent and the plant is throwing out new shoots and looking healthy. Some of the plants are still curly; I suppose there is still *Psylla* on them, and I think that another spraying would put these right. I am very pleased with the result and if the second spraying puts the whole field right as I think it will, and the disease does not at once return, then I expect the plant to give seed, of which at first I had very small hopes.

*Seeraha P. O.,
Champaram.*

... ..
 "I think the plant has benefited a lot. I had better looking stuff than the bit I sprayed, but scattered over the *zilla*, so it was more convenient to do the bit near at hand and in one field. Now I have had to dig out nearly all the *zilla* plant which was at first best, as hopeless, the sprayed stuff being about all I have worth keeping. I wish I had got at the plant on the first appearance of disease as it got a set back before I started spraying it, but I think it will seed now."

... ..

Plant sprayed here (Pusa) has benefited very markedly; the tops have grown through with clean foliage, the curling has ceased, the *Psylla* has disappeared almost entirely and the whole plant becomes green. At the same time this has not been followed by a recrudescence of the disease as in the main the natural enemies of the *Psylla* are not affected by the spraying.

A very remarkable improvement was effected at Sirsiah by spraying, but as the value of the plant there was out of all proportion to the cost of spraying, we sprayed steadily every ten days till satisfied that *Psylla* really was wiped out. Had we been able to commence this treatment earlier, the Sirsiah plant would have suffered much less. Neither at Pusa nor at Sirsiah has spraying affected the incidence of X; it has rendered healthy all plant infested with *Psylla* which was free from other diseases and in this way has made a marked improvement.

Spraying has been recommended for plant kept for seed because of the value of seed plant; it is impossible to spray all koontie plant at present, but it is not difficult to spray, and knowing what the cost is, it is possible, for each Concern to see

whether spraying is worth while. For spraying large areas, a mechanical bullock-drawn sprayer, doing 15 to 20 bighas per day, would cost about Rs. 300. This would require much less labour than 10 auto-sprayers doing the same area and costing as much ; but it would require very good arrangements for supply of soap solution.

THE IMPROVEMENT OF INDIAN WHEAT.

BY

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[A Paper read at the Punjab Agricultural Conference, Lyallpur, November 4th, 1912.]

THE importance of the wheat crop to India both as food for the people and also as an article of export is well known. The average annual outturn is over 8,000,000 tons a year and of this about 75 per cent. is produced in Northern India. Any improvement in the production of this crop, either as regards yield or quality, would mean a large annual addition to the wealth of the country.

On account of the important position held by this crop in India, the subject of wheat improvement was one of the earliest taken up by the Board of Agriculture and this question was fully discussed at the second meeting of the Board in 1906. Six years have now passed and very important results on a large scale have been obtained in many parts of India such as Behar, the United Provinces and the black cotton soils of Central India. Briefly summed up, it may be said that in tracts in which the normal outturn is 8 to 10 maunds of poor wheat the yield has been raised to 25 to 30 maunds, and the type of wheat grown has been classed in England as among the best on the London market. The methods

by which these improvements have been effected have been found to apply not only to *barani* conditions but also to canal-irrigated tracts. An account of the work already done will, therefore, be of interest to the Punjab, the Province which produces about 35 per cent. of the total wheat crop of the Indian Empire.

This work has also an important bearing on the export trade in Indian wheat, for it is clear that any large increase in production will at once swell the volume of wheat shipped from Karachi. One of the primary requirements of the export buyer is a well-grown even sample. Such samples fetch higher prices in the world's markets than badly grown wheat. To obtain such samples good cultivation is essential and any improvements in the methods of production, which will lead to this result, form an important factor in the development of the export trade.

The main lines of improvement are two in number :—

1. *Agricultural improvements* by which the yield has been greatly increased and the appearance of the wheat to some extent improved. In the alluvium of the Indo-Gangetic plain these agricultural improvements consist in the union of hot weather cultivation and dry-farming methods ; combined, where necessary, with green-manuring.

2. *Improvements in the kinds of wheat grown* by which not only the yield and general agricultural fitness of the wheats have been increased but also the quality of the grain.

We propose to deal in the first place with the agricultural aspect of the question.

I.—AGRICULTURAL IMPROVEMENTS.

One of the most striking features of the wheat production of India at the present time is the comparatively low outturn obtained by the people. The question arises, "Can this outturn be increased with the means at the disposal of a well-to-do cultivator or zemindar ?" The answer is, "Most emphatically yes." The methods by which crops, at least twice those now produced, can be grown in the alluvium of the Indo-Gangetic plain were first worked

out at Pusa during the years 1906 to 1910 and are now being taken up on a large scale in Behar and the United Provinces. These methods consist in the following :—

1. Exposing the soil to the sun and air *as soon as possible* after the *rabi* crops are harvested. This sweetens the land, tends to kill weeds and also leaves the soil in a proper condition to absorb the whole of the early monsoon rainfall. This exposure of the land should be done as soon as the *rabi* crops are harvested and if the showers, which often fall at this time, are utilised, a good deal can be done to break up, by means of spring time harrows, the sun-baked and hardened stubbles. The easiest method in canal-irrigated tracts is to water the stubbles first of all and then to cultivate the land thoroughly, but the extent to which this can be done is limited by the water-supply and the cattle power available. The great benefits obtained by hot weather cultivation are recognised by the people of the Punjab and are referred to in *Punjab Proverbs*. These benefits, however, are not sufficiently appreciated and realised in practice.

2. Water conservation and the proper application of irrigation water. To obtain a really good sample, the water-supply of the crop must be properly regulated. This means in *barani* tracts that all possible methods of conserving the available moisture must be adopted. The chief means by which water can be conserved are by clean cultivation and moisture conservation during the monsoon period, by which weeds are destroyed and as much rainfall as possible absorbed and retained up to sowing time, and by harrowing the land after sowing. By clean cultivation is meant the destruction of weeds by ploughing and harrowing, while the importance of moisture conservation in India is sufficiently evident. This conservation of moisture consists in maintaining a dry surface mulch by means of the harrow, which prevents the loss of water by evaporation during the long breaks in the monsoon. By harrowing the land after sowing, so as to break up surface crusts, a dry surface mulch is formed, which retains the moisture. Lever harrows are very useful in this respect, and have been used in Behar with great

success. In canal-irrigated tracts the wheat crop would be benefited by the use of these harrows after the first irrigation. On the other hand, over-watering must be avoided. In canal-irrigated areas there is a tendency to apply too much water to wheat. This results both in diminished yield and also in loss of quality. The ryot often forgets that wheat is a crop which does not need much water.

3. Keeping up the supply of organic matter in the soil when necessary by occasional green-manuring with *san*. This is done during the monsoon period immediately before the wheat crop. In those tracts which grow *arhar* or *rahar* (*Cajanus indicus*) the fall of the leaves and flowers helps to keep up the supply of organic matter. The purpose of this organic matter in the soil is to increase the fertility, to improve the tilth and the water-holding capacity of the soil. In wheat growing this green manuring is particularly necessary on the lighter lands.

These improved agricultural methods can be summed up as the union of hot weather cultivation with dry-farming methods, combined with occasional green manuring to keep up the store of organic matter.

The effect of this method of cultivation on the wheat crop is extraordinary. A fine crop is the result and the yield is increased at least 100 per cent. Further, the appearance of the wheat sample is improved and such wheats are better filled and *take the eye* more than those grown in the ordinary way. The result is more wheat and better wheat; and these improved methods, wherever they have been properly tried in the Indo-Gangetic alluvium, have always given the same result. They apply both to *barani* conditions and also to canal and well irrigated tracts and to all classes of wheat. At Pusa crops of 25 to 30 maunds are obtained as a matter of course. On many indigo estates, in Behar, the Pusa results have been repeated and even exceeded. In both Behar and the United Provinces cultivators and zemindars have obtained similar results. At Cawnpore, similar crops have been obtained by Mr. H. Martin Leake for several years on a large scale—25 to 30 maunds of

wheat to the acre have been grown with half the quantity of canal irrigation ordinarily used for this crop. At Gurdaspur in the Punjab, similar results were obtained for the first time in the *abi* harvest of 1912.

II.—INTRODUCTION OF IMPROVED WHEATS.

The second line of advance in increasing the wheat production of India is in improving the wheat plant itself, that is, in the creation of better kinds of wheat by selection and hybridisation. The essential points in this are :—

1. Increase in yielding power.
2. Improvements in general agricultural fitness including rust resistance, standing power and hardiness.
3. Improvement in the quality of the grain.

That any improved wheat must yield well and also possess general agricultural fitness for growth in any particular tract is obvious, and needs no particular emphasis. A cultivator will never be satisfied with a wheat unless it yields well and can be grown to perfection. The question of quality of grain, however, requires some explanation. In considering grain quality it must be borne in mind that about 90 per cent. of the wheat grown in India is eaten by the people, and that only the balance finds its way into the export trade. Any improvement in quality, to be of importance, must satisfy both classes of consumers—the people of India on the one hand and the Home millers on the other. It is fortunate that the class of wheat most liked by the people for food is that which is worth the most money on the home markets. This is a most important point and one which cannot be emphasised too strongly. On many occasions the Pusa improved wheats along with ordinary samples have been shown to cultivators, and they invariably prefer for their own food the kinds which have done best in the milling and baking trials in England. A large number of landholders and educated Indians have eaten these new wheats, and are loud in their praises of the superiority of these types over those which can be purchased

in the Indian market. There is therefore no antagonism between the demands of the people and those of the home markets. Both prefer the same general grade of wheat.

The chief points concerned in the quality of wheat are as follows :—

1. The sample should be well grown and the grains should be even in colour and uniform in consistency like the sample of Pusa wheats exhibited at this Conference. The colour should be white or red, not a mixture of the two. The wheat should be free from dirt and other seeds, such as barley or gram.

2. The consistency should be glassy or flinty rather than soft. The wheat should mill well and should absorb a large amount of water in the milling process. Most of the Pusa wheats take up about 10 per cent. of water in the milling process and are ground in the mill with the minimum amount of trouble. Millers naturally lay great stress on these points.

3. The skin should be thin, so that a large percentage of flour is obtained. Fortunately this applies to most Indian wheats, but this point should not be forgotten in the work of producing new kinds.

4. The percentage of nitrogen should be high and the flour should be greyish white in colour. It should be strong, that is, capable of yielding large well piled loaves like those of Manitoba No. 2 and Pusa 4 illustrated in Pusa Bulletin No. 22. Greyish white flour and toughness of dough are points appreciated also by the Indian consumer, and the superior food value of such wheats is well recognised in India.

5. Other things being equal, the wheat should be a white wheat rather than a red wheat as white wheats give, as a rule, a whiter flour than red wheats. In the Punjab a higher price is often paid for white wheats than for red, so that an effort should be made to conform with the custom of the trade and to produce improved white wheats. This has always been done at Pusa and the new wheats now being grown in Behar, the Central Provinces and the United Provinces are without exception white wheats. There is, however, no objection to high quality red wheats

in the home markets. The best wheats on the English market, namely, Manitobans, are red wheats. Further, red wheats are considered to be hardier than white wheats.

The Pusa wheats exhibited to-day at this Conference illustrate the various points of quality which should be aimed at and a comparison between these new wheats and those which are now exported from Karachi will show what an enormous amount of work remains to be done in improving the quality of the wheats now shipped from the Indus Valley.

In deciding the many and intricate questions of quality which have arisen in improving the wheats of this country, India has been fortunate in obtaining the active interest and co-operation of the highest authority in the empire on questions relating to the milling and baking of wheat. I refer to Mr. Humphries, a former President of the Incorporated Association of British and Irish Millers, who, during his period of office, was largely instrumental in bringing about the present form of contract by which the adulteration of Indian wheats exported to England was reduced to a minimum. All the new Pusa wheats have been milled by Mr. Humphries and then made into bread. His opinion on these improved Indian wheats has been endorsed by the Council of the National Association of British and Irish Millers and by the milling press in Great Britain. The Pusa wheats have been examined by the Liverpool and Calcutta Millers and also by the chief wheat exporting firms of Bombay and Karachi, and they all agree with Mr. Humphries. The best technical and trade opinions in the Empire have thus been obtained on the question of quality and on the class of wheats which will find most favour at Home. This testimony has been singularly unanimous, and Mr. Humphries' opinions have been universally accepted.

Up to this point the two lines of progress in improving the wheat production of the Indo-Gangetic plain have been kept separate. These two lines of progress are :—

1. *Agricultural improvements* by which the yield of wheat can be increased.

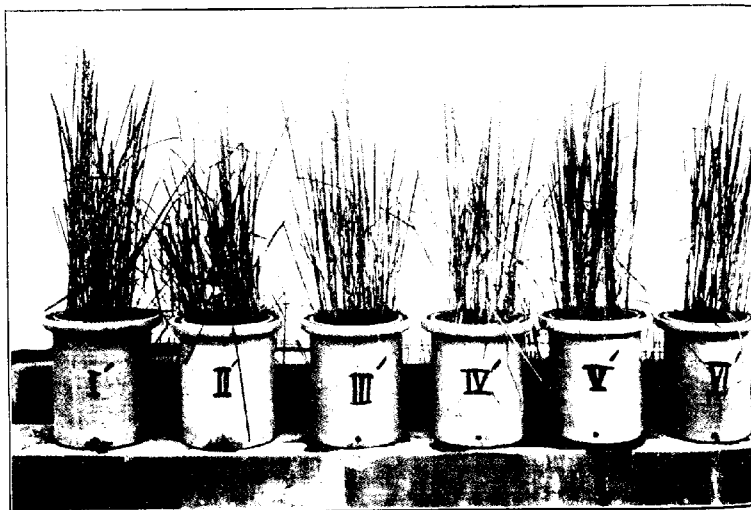
2. *Improvements in the kinds of wheat grown.*

There is, however, an intimate connection between these two lines of progress which must now be indicated. To produce the greatest yield the crop must be well grown and the sort of wheat cultivated must be one with high yielding power. To get the highest price the wheat must also be of good quality. To obtain the best outturn from an improved wheat it must be properly grown, just in the same way as a good horse or a good pair of plough cattle must be properly fed if they are to do their work well. To extract from the soil the largest possible profit we must use not only improved methods of agriculture but also grow better wheats. It is only in this way that high yield and high quality can be combined and the cultivator can be shown how to get the greatest monetary return for his labour.



FIG. 1.—UNDRAINED.

7th October.



A. J. I.

FIG. 2.—DRAINED.

EFFECT OF DRAINAGE ON RICE SOILS.

BY

C. M. HUTCHINSON, B.A.,

Imperial Agricultural Bacteriologist, Pusa.

A SET of pot cultures of rice plants was undertaken at Pusa in connection with an attempt to discover some of the soil conditions under which the Ufra disease of rice, at present under investigation, is likely to occur. The results obtained appear to be of sufficient interest to warrant their publication separately as indicating the effect of varying soil treatment upon the growth of this crop.

Seedling plants of the same age and variety were locally obtained, and planted out in twelve glazed earthenware pots, 10 inches in diameter and 12 inches deep; so far as possible the same number of plants was used in each pot.

Work in Italy by Brizzi on an apparently similar disease known there as "brusone" had resulted in establishing an apparent connection between lack of aeration of the water in which the plants were growing, and the incidence of the disease. • In order to test any possible similar connection in the case of "Ufra," the twelve pots were divided into two series; in those numbered I to VI drainage was prevented by plugging the tubulure at the base of the pot, whilst in VII to XII this was left open, the intention being to renew the water-supply of the latter series from the top constantly, and so convey air through the soil. After two days, however, it was found that, owing to the close texture of the soil used (a local rice soil), no drainage was taking place in the second series, and a third series, numbered I' to VI',

was started, in which a layer of cinders 2 inches thick was placed at the bottom of each pot. With this arrangement comparatively rapid drainage took place; in each pot an average depth of 3 inches of water was maintained above the soil throughout the experiment; in the drained pots it was found necessary to renew the water during the first ten days at intervals of 48 hours, about 2 inches of water having apparently drained through the soil in that time; during the second ten days this rate of flow was gradually reduced, the same amount of water passing, towards the end of this period, in about twice the time. The pots were not under cover, so that rain prevented any exact measurement of the amount of water actually supplied.

Further differences of treatment consisted in a preliminary air-drying of some of the soil and the addition of oilcake (mustard at the rate of 15 mds. per acre = 60 lbs. Nitrogen) to certain pots. Thus every alternate pot in all three series contained soil which had been airdried before filling in. Cake was added to Nos. I, II, VII, VIII and I', II'.

Two additional pots, XIII and XIV, were filled with soil from Noakhali, taken from fields in which the "Ufra" disease had been so bad the previous season as to render the crop worthless. To the soil of one of these, No. XIII, lime, oilcake and green manure (*Crotalaria juncea*) were added; No. XIV had no treatment. The transplanting into pots was carried out on 5th September 1912, and photographs were taken on 7th October, 30th October, and 26th November.

The first observed difference was in the pots to which cake had been added, Nos. I, II, VII, VIII, I', II' and XIII. After 32 days' growth after transplanting, all the plants in these pots had turned brown and appeared withered and moribund; this condition is shewn in Plate V.

This effect appeared to be due to a direct toxic action of the products of decomposition of the cake; laboratory experiments carried out at the same time shewed that no nitrification was going on in the saturated undrained soil, but that certain anærobic organisms were producing foul smelling decomposition products



FIG. 1. UNBRAINED.
30th October.

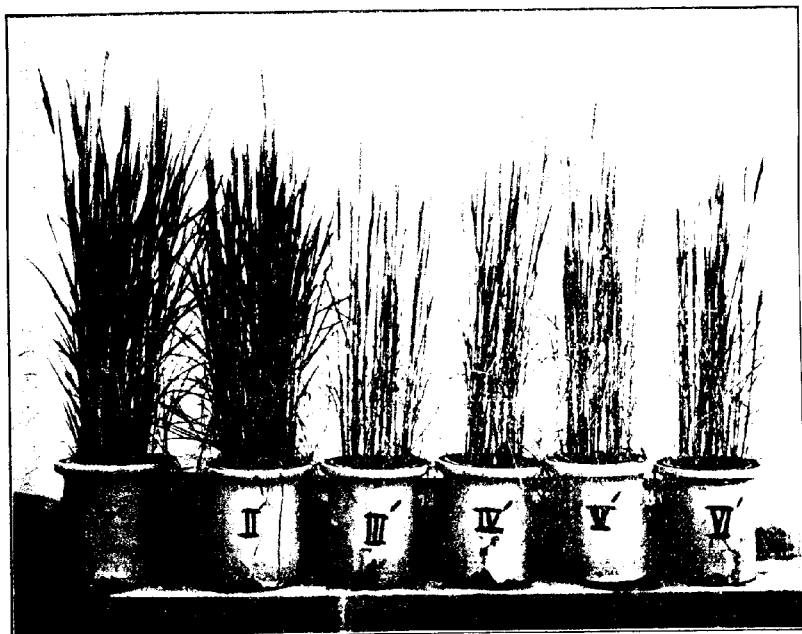


FIG. 2. DRAINED.

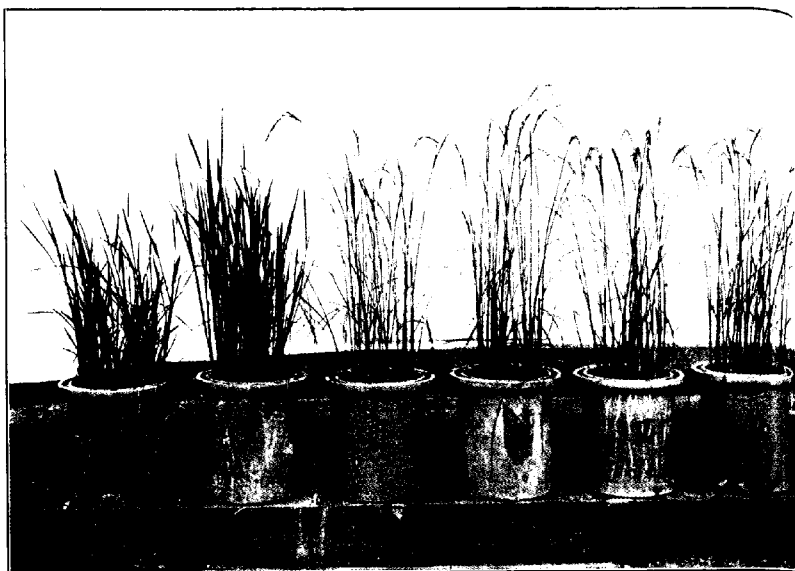
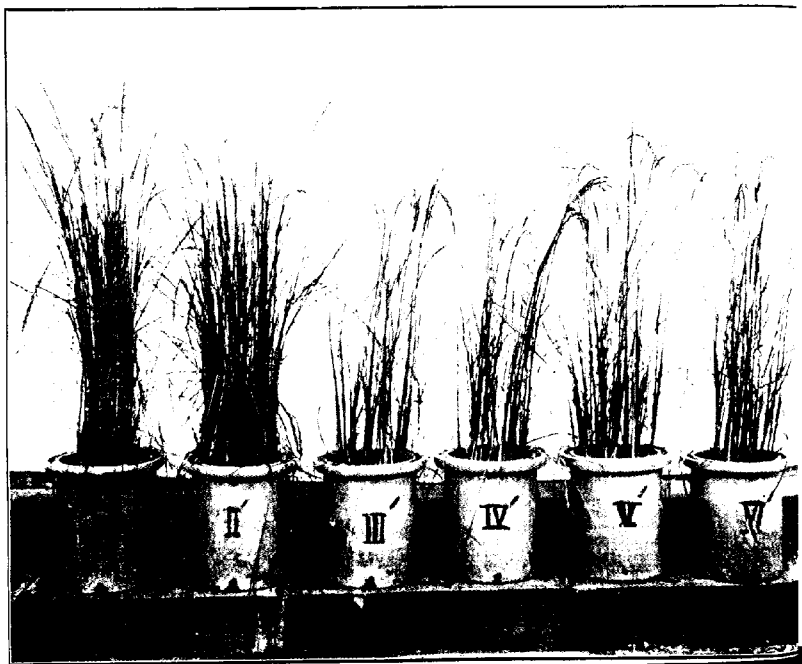


FIG. 1.—UNDRAINED.
20th November.



such as indol, and gases including nitrogen, marsh gas, and carbon dioxide. These gases produced cavities in the soil, similar to those formed in solid sugar media, such as glucose gelatine, by gas producing bacteria; and as the gases gradually escaped through the soil and their formation ceased, these cavities collapsed, and in the case of the well-drained soils the toxic products were carried away by the percolating water. That this was actually the case may be inferred from the comparatively rapid recovery of the plants in pots I' & II' which took on a healthy green colour many days before those in I, II, VII and VIII, and eventually made a good growth.

This form of decomposition of organic matter is common in swamp conditions, and the rice plant is no doubt partially immune to toxic products of such anaerobic action, although other plants not naturally immune are rapidly killed off by accidental swamping, although they will flourish in running water. When, however, the accumulation of toxic bodies becomes unduly great, as in the pots Nos. I, II, VII and VIII, the rice plant suffers correspondingly, whilst in Nos. I & II the percolating water prevented the accumulation of toxins to this extent.

Plate VII taken on 26th November, 11 weeks after transplanting into the pots, illustrates the final effect upon the crop. It will be seen that the manured plants in the undrained series, although they attained an apparently healthy green condition after recovering from the first ill-effects of the cake, are stunted as compared with those in the drained series, and actually formed no grain at all, being still green and immature. At the same time Nos. I' & II' in the drained series, to which cake was added, although vigorous and healthy, formed but little grain, the ears not having matured properly and the grain being light and not well filled.

One of the most marked differences produced by the addition of oilcake was in the tillering of the plants, which was greatly increased by the supply of nitrogen in this form. In the original transplanting the same number of plants, as nearly as possible, was put in each pot; in the table of results the number of stalks harvested shews the great variation due to tillering.

One of the most interesting results of this experiment is afforded by the growth of the rice in the two pots XIII & XIV filled with "Ufra" soil. No. XIII which received lime, cake and green manure, suffered at first (7th October) from intoxication, but eventually recovered (30th October) and made a good growth. It was found, however, on 26th November, when the last photo was taken, that No. XIV which had had no treatment of any sort, not only produced more grain than No. XIII, but gave the best return of any pot in all the series. This is good evidence of the fact that rice soils vary profoundly amongst themselves without showing very much difference either by chemical or mechanical analysis. Unfortunately the sample of this soil obtained was not large enough to allow of comparative treatment under drained and undrained conditions.

An interesting difference is noticeable in the root development of the plants in the two series, and is shewn in the photograph (Plate IX). Only one plant from each series is shewn, as the difference in root development illustrated was absolutely characteristic of every pot.

In the undrained pots the development below soil level leaves the original long stem of the transplanted seedling with a bunch of roots at its lower extremity and long adventitious roots proceeding from the two nodes above it; in the drained pots, however, the lower part of the stem has rotted away, leaving the upper half only, with a much more fully developed bunch of roots from the remaining extremity, and practically no adventitious roots from the upper node. This, I think, may be said to be exactly contrary to the expectation of a deeper root system in a better drained soil. The explanation suggested is that the plants were obtaining food of two different kinds depending upon two different sets of conditions. In the undrained soils anærobic conditions prevailed, and the plants were dependent on food produced by anærobic organisms; probably nitrogen as ammonia would be the predominant factor in this supply; consequently most food would be available where the anærobic conditions were most pronounced, *i.e.*, at the bottom of the pot. In the drained soils different bacterial conditions would obtain

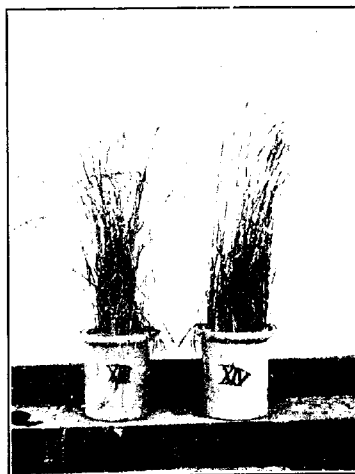


FIG. 1.—7th October.



FIG. 2.—30th October.

"UFRA" SOIL.



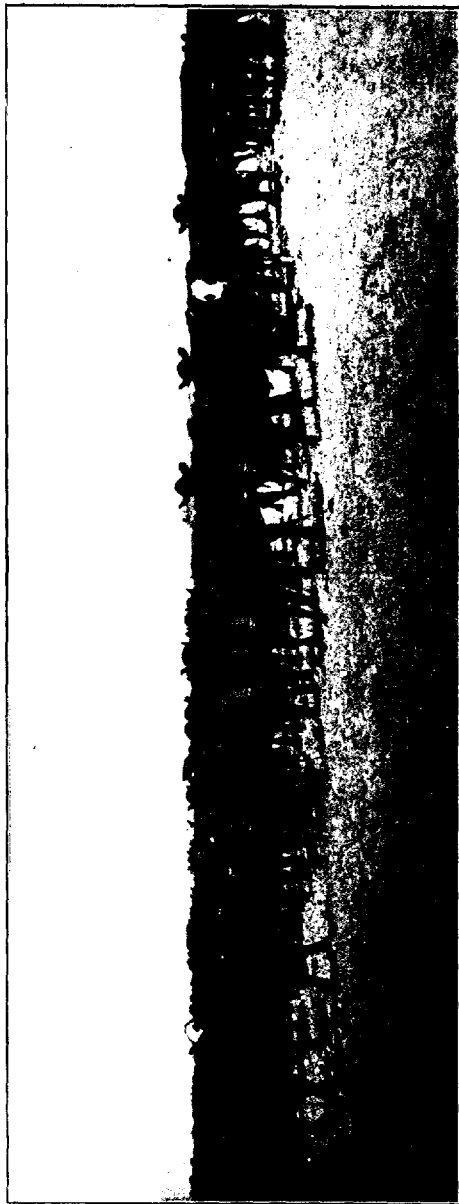
A. J. J.

FIG. 3.—26th November.

Rice Pot cultures.

NUMBER.	Treatment.	Condition.	WEIGHT IN GRAMS OF				Number of stems harvested.	Ratio.	
			Crop.	Grain and chaff.	Grain.			Grain.	Stem.
I	+ Cake	Airdried.	...	...	...	...	...	...	...
III			78	20	19.5	...	22	19.5	...
V			108	27	26.0	45.5	22	26.0	...
VII	+ Cake		...	...	...	...	...	...	...
IX		Undrained.	132	31.5	30.5	...	28	30.5	...
XI			93	24.5	23.5	...	27	23.5	...
II	+ Cake		...	...	...	...	...	...	...
IV			99	25.5	24.5	46.0	24	24.5	...
VI		Undried.	96	22.5	21.5	...	26	21.5	...
VIII	+ Cake		...	...	...	...	...	...	...
X			103	27.0	25.5	...	20	25.5	...
XII			103	23.0	21.5	...	24	21.5	...
I	+ Cake	Airdried.	366	42	33	...	55	33	...
III			115	28.0	26.5	...	28	26.5	...
V			149	34.0	32.5	59.0	27	32.5	...
II'	+ Cake		325	35.5	28.5	...	52	28.5	...
IV'		Undried.	122	35.0	33.5	...	30	33.5	...
VI'			137	30.5	29.5	63.0	29	29.5	...
XIII	"Ufra" soil + cake & lime + green manure.		303	38	28.5	...	59	28.5	...
XIV	"Ufra" soil untreated.		256	56	54.5	...	71	54.5	...

PLATE X.



YOUNG STOCK ON A RANCH, TEXAS, FROM ENGLISH BULLS.

A. J. L.

DRY FARMING.

BY

G. S. HENDERSON, N.D.A., N.D.D.,
Deputy Director of Agriculture, Sind.

Of late years much has been heard about Dry Farming, and, largely owing to subsidised or interested publications from the United States of America, it has received much mention in the press. The name is somewhat misleading, it simply means farming conducted in semi-arid regions without irrigation. In arid and semi-arid countries there are tracts of land which were formerly considered only of value for stock rearing, which gave a scanty yield of grass, requiring immense tracts to pasture the stock. It is obvious if speculators could acquire these lands cheaply, break them up into small farms and sell to colonists, then much money could be made. Much of the "boosting" of dry farming can be traced to the efforts of those speculators to attract settlers to make homesteads in the Great Plains lying to the East of the Rockies in the centre of the U. S. A.

In connection with dry farming, statements have been made that so-and-so's 'system' is the only method of any use, and that various systems are applicable to all conditions of semi-arid countries. Also that any country, with a rainfall of between 10 and 20 inches, is suitable for dry farming. The United States of America Department of Agriculture have always maintained a cautious attitude in regard to dry farming. In various stations they are working out arid cultivation problems systematically.

Many people have suggested that the Indian Agricultural Department should conduct extensive dry farming experiments

especially in the districts which are subject to famine conditions. A visit was made by the writer to the Southern end of the Great Plain of the U. S. A. in 1911 to see dry farming carried out under conditions somewhat similar to those pertaining to India.

To compare different localities in this connection it is necessary to look at the following points :—

I. *Rainfall*, annual amount of precipitation, distribution during the year, percentage run off from land.

II. *Temperature*, annual range and mean temperature, duration of frost if any, and dormant season, amount of evaporation, existence of hot winds.

III. *Soil*, physical character whether retentive of moisture, natural features such as hollows between hills forming natural catchment basins.

In North Texas and part of New Mexico the natural conditions are more similar to those found in India than other parts of the Great Plains. This forms the Llano Estacado or Great Staked Plain. It extends to 50,000 square miles and stands 5,000 feet above sea-level. The soil is generally a brownish loam and is covered with buffalo grass (*Bouteloua digostachya*). this is hardly visible during the dry spells but springs up after rains and the whole country looks green. The surface varies from level to small rolling hills with flat tops not unlike parts of the Deccan. The temperature varies from a maximum of 110° F. to 5° F.

The various "systems" in vogue are all earnestly advocated by their originators as suitable for all conditions. Some systems advocate deep ploughing, others shallow ploughing and summer fallowing with wide spacing and thin seeding of the crop, others pressing by the sub-soil packer (a roller made up with loose iron discs) and all generally agree that a dust mulch should be kept on the soil as far as possible all the year round. This dust mulch is an inch or two of fine soil on the surface; it breaks the capillary connection with the soil and atmosphere and so minimises evaporation, and it also readily absorbs any rainfall.





(a) JUARI CROP, AMARILLO.



(b) SUBSOILING, AMARILLO.



A. J. I.

(c) BUFFALO, ONE OF THE FEW SURVIVORS.

The underlying principle is to keep the soil receptive and retentive of moisture and the retention of the dust mulch does this; the soil being carefully cultivated after every fall of rain where possible.

The U. S. A. Agricultural Department recommend no system but believe in modifying their methods according to varying conditions, and farming according to the common rules of good husbandry for humid regions. They are also paying a great deal of attention to selecting drought resisting plants and breeding them up, also to the collection of suitable varieties from foreign arid countries. They have a large staff of plant collectors who travel all over the world on the look-out for promising introductions.

Amarillo is the site of one of the United States of America experimental dry farms. It is quite a new city on the Rock Island Railway. Round about, a large number of farms have been cut out of the old ranches, much to the disgust of the original stockmen. The city is situated in a flat plain. The rainfall in 1911 had been less than 15 inches, and the crops, chiefly jowari, maize and cow peas were looking very poor. In India such crops would probably have received remission of the land tax. The farmers generally elect to put in as large an area of cultivation as they can, and in a year of good rainfall do fairly well. Most of the farmers cannot afford to go in for very elaborate cultivation. Their ploughing is shallow and the crops are drilled wide apart, and between the rows intercultivation is done from time to time. The general opinion among settlers seems to be that summer fallowing does not pay and neither does sub-soiling. One farmer stated that he was pleased when he obtained 15 bushels grain per acre every second year. Land is selling at 20-30\$ per acre for 'made farms.' Here and there some especially good results are reported, but they are generally due to special circumstances, such as neighbouring hills forming a catchment basin or seepage water percolation from high land laid on impervious clay.

The crops on the Government Farm at Amarillo were much above those of the neighbouring farmers. About 80 acres are

under cultivation. The rotation generally is jowar followed by 2 small grain crops, generally wheat and oats. Yields up to 30 bushels are obtained. Summer fallowing is not recommended as it is not considered profitable. An occasional sub-soiling about 10" deep every few years is beneficial.

It is very doubtful, however, if such expensive working of the soil pays; and the land is not safe till the crop is of a fair height, as high winds occur occasionally and blow away the dust mulch, leaving the land dry.

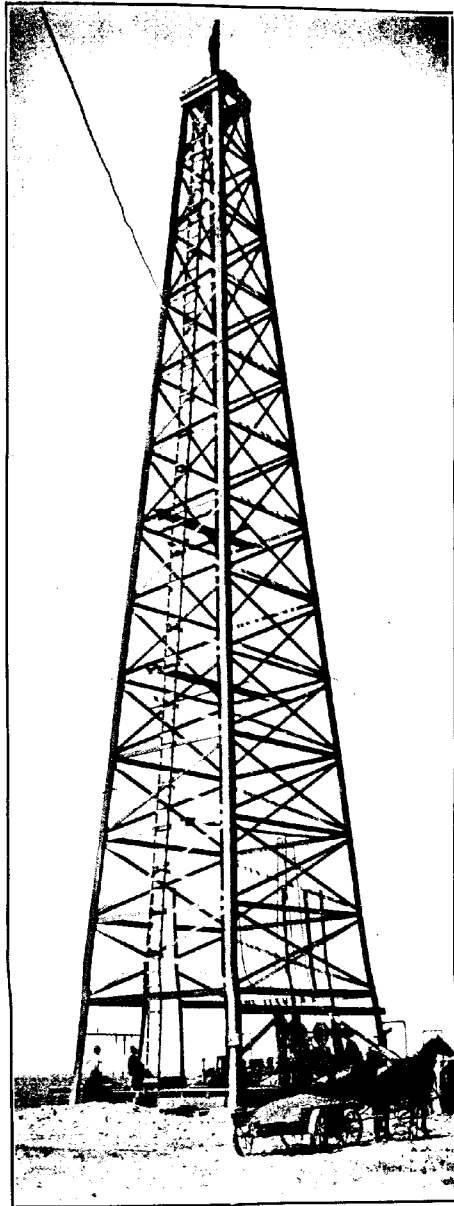
Dalhart is another U. S. A. Agricultural Department dry farm station. It is to the north of Amarillo. It is situated a short distance outside a brand new and bustling little city of that name. The country is more rolling towards the north, with the usual reddish soil, and quite treeless. Most trees will not grow, and the winds affect others badly. Round some farms, however, may be seen catalpas, Russian mulberry and Osage orange, which are all drought resisters and quick growers.

Drinking water is a problem for the towns, and artesian wells are being made in some cases. In the photo opposite of a super-structure of a bore the depth reached was over 800 feet and was being deepened.

Some good stock can be seen on the ranges while passing; they are generally the produce of pure bred bulls. A few buffaloes (bison), can still be seen in a semi-wild state, it is only a few years since they could be seen in the plains in thousands.

When capital is available the plains are very suitable for power cultivation, the large flat unbroken prairie forms an ideal ground for steam and oil engine tackle. The work can be pushed on very quickly, which is a matter of great importance. Generally direct tractors are used. "Gasoline" tractors are coming into fashion. Plate XIV shows a plant being worked and drawing a cultivator, packer and drill behind it. The working crew live in the "caboose" shown in the background while on tour.

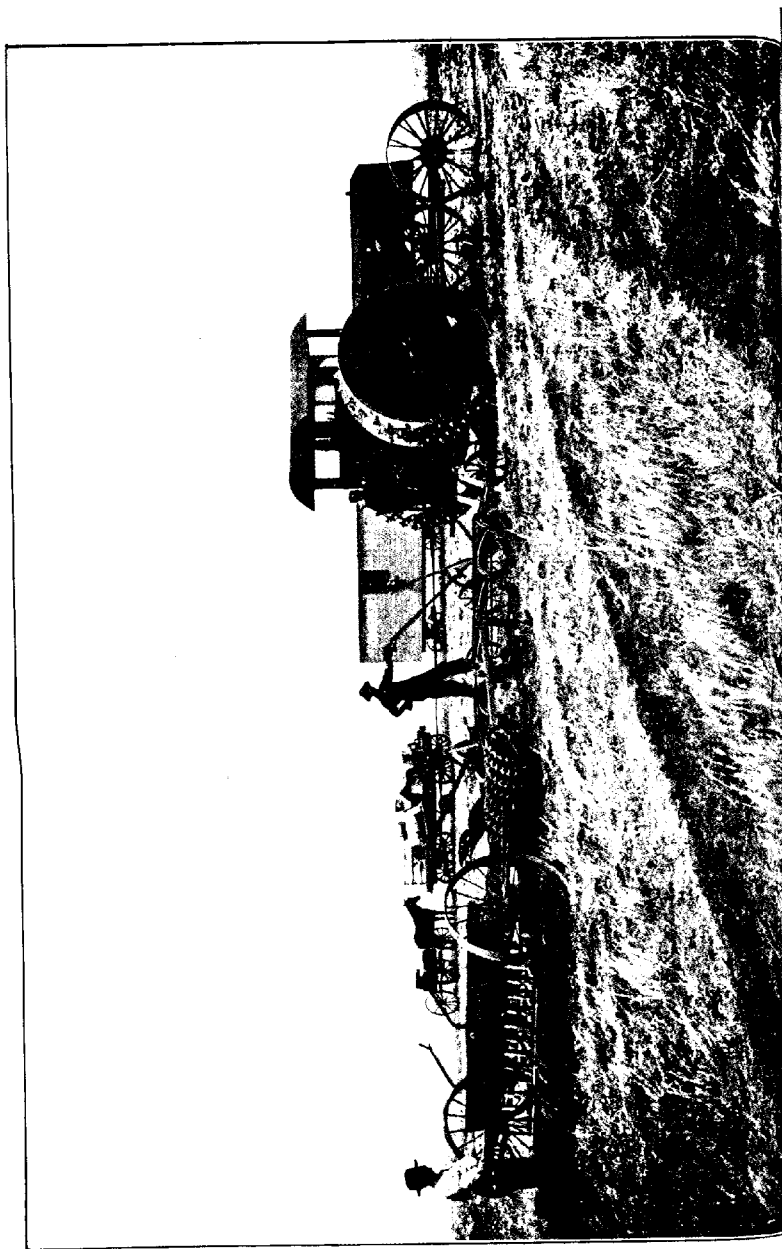
The Dalhart farm, under the charge of Mr. W. D. Griggs, has been running for 4 years and much interest is taken in it by



A. J. I.

ARTESIAN BORE, DALHART, TEXAS.

PLATE XIV.



neighbouring farmers. Like Amarillo the land and buildings are supplied by the township, while the U. S. Agricultural Department supply the staff. The farm crops, owing to a dry season, were below average, but much better than neighbouring crops. This part of the country is very subject to high winds, so the top surface of the land is generally left fairly rough, being finished off with a disc plough. A wind over 50 miles an hour will blow the whole surface from a field if loose and uncovered. It has been recorded that a newly manured field has had the manure completely blown away, and deposited on neighbouring land.

A method recommended by the station is to plough 8" deep in the Autumn and give 4 workings in the Spring, leaving the surface rough with the disc plough. Then sowing is done, the drills being $3\frac{1}{2}'$ apart and 1' between plants in the rows. Plate XV shows the difference in size of crops with this method in comparison with only a 3" ploughing in spring. A common rotation is

Kaffir corn
Milo
Sorghum
Cow pea.

Kaffir corn is jowar with loose ear heads and Milo is jowar with compact heads. 20 bushels per acre is considered a good yield on the farm.

The opinion of the Dalhart farm staff is that where the rainfall is less than 18" per annum the other circumstances being favourable, the crops will be very doubtful. On the plains there is little snow in winter and frosts are light. Evaporation on the other hand is very high.

Going through Oklahoma, Kansas, towards the East it is interesting to note how as the humid region is approached the crops improve till the typical maize and lucerne country is reached.

Mr. Chilcott, in charge of the dry land investigations, U. S. Department of Agriculture, has laid down the following

conclusions in the current year book of the Department. They are most important, and show the views of the Government based on carefully conducted experiments at many stations, and can be compared with the loose and inaccurate statements often put forth in dry farming publications.

SERIOUS MISCONCEPTIONS CONCERNING DRY FARMING.

I. "That any definite 'system' has been or is likely to be established that will be of general application to any considerable area.

II. That any hard-and-fast rule can be given to govern methods of tillage in time and depth of ploughing.

III. That deep ploughing necessarily increases water holding capacity of soil.

IV. That alternate cropping and summer tillage can be relied on as a safe basis for permanent agriculture or that it will overcome effects of drought.

V. That definite rules can be laid down to operate a dry land farm."

In regard to the application of American practice to India it would seem that the largest field lies in the selection and breeding of drought resisting plants and in the collection of economic plants from foreign arid countries.

More cultivation would in famine districts render the lands more receptive and retentive, but generally the cultivators are unable to do this after a bad year, their cattle are scarce and in bad condition, and are not strong enough to pull heavier and more efficient implements even if they possessed the latter. It is interesting to note in this connection that the practice in the "bosi" lands of Sind follows out American practice very closely. Here the "bosi" land receives a 5" or 6" watering in August. On drying it is carefully ploughed several times and gone over with a very heavy roller till a dust mulch is made on the surface. In October wheat, etc., is drilled down into the moist soil and the crop receives no further irrigation.



A. J. I.

JOWARI PLOTS, CROP ON RIGHT PLOUGHED 8" DEEP IN AUTUMN.

" " " LEFT " 3" " SPRING.

THE PROBLEM OF THE IMPROVEMENT OF THE
INDIGENOUS COTTONS OF THE UNITED
PROVINCES.

BY

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IN Vol. VI, Part I, of this Journal for January 1911, appeared a reprint of an article entitled "The Problem of the Improvement of Cotton in the United Provinces" which was written originally in connection with the Agricultural Conference held during the Allahabad Exhibition and to explain the cotton exhibits at that exhibition. During the two years that have elapsed considerable progress has been made in the experimental and practical work on the indigenous cottons which is being carried out by the United Provinces Department of Agriculture, and the interest which is being taken in this work, render it advisable, in the absence of detailed reports on the subject, to review the present position of this work.

The work falls into two clearly defined sections—the experimental and the economic. It is first necessary to find, or to produce, some type, or types, which will yield a greater return to the cultivator than the present mixture grown by him. It is, then, necessary to develop an organisation, which takes into account the economic aspects of the problem, for the replacement

of the local mixture by these types. We hope to show in this note how far these objects have been realised up to the present moment.

Before, however, it will be possible to indicate this, it is necessary to outline certain fundamental principles, based partly on economic facts and partly on the nature of the cotton plant—which it is necessary to keep prominently before the mind if success is to be attained and an improvement of the cotton crop is to become established.

The outstanding features of the cotton problem of to-day are the proximity of a world's shortage of the raw material and, as the problem more nearly affects Britain and British possessions the development of the mills in America. In practice this means that America will continue to absorb more and more of her own produce and that by that amount will the supply to Lancashire be diminished. The cry in Lancashire is for more, and still more, cotton. The quality of that raw product is of secondary importance. The world's mills may be divided roughly into two classes—those spinning fine counts* and those coarse counts of 20's and under. The bulk of the Lancashire mills fall into the former group and require as raw material a fairly long staple. This is found in the American cotton, from which country the bulk of the raw material comes, though a number of other cotton-growing countries, especially Egypt, and India also to a certain extent, produce cotton of the required quality. Low counts are spun very largely on the Continent, in India and in China, and recently in Japan. In the face of a world's shortage, or at least a shortage in the Orient, any increase in the supply of raw material is beneficial. There is sufficient latitude in the mills of the two types above indicated to produce an adjustment which is largely automatic. A large increase in the raw material suitable for spinning low counts will lead to a lowering of cost and, automatically, a certain amount of raw material suitable for

* Spinning 40's and upwards, i.e., spinning yarn giving 40 or more hanks to the pound. A hank being 840 yds. of thread, it is clear the higher the count the finer the thread and the longer the staple required to produce the necessary strength.

higher counts will be liberated. We may conclude, then, that the main object is to produce an increase of the supply of raw material *of any quality*, and we are inclined to think that this is the true definition of the cotton problem of the world.

The first and, probably, the most obvious, method of increasing this supply is to increase the acreage. It must not, however, be forgotten that the acreage put under a particular crop in a given area is the resultant of many economic factors which are only partially under control. Thus, of the economic conditions which hold for the United Provinces, the guiding factors are the small size of the holdings and the absence of the capital. The first object of the cultivator is to provide food for himself and family and after that for his domestic animals. Having arranged for the supply of these, he is then in a position to consider what is the most suitable, or most valuable, crop he can grow in the remainder of his tenement subject to such limitations as are imposed by questions of suitability of land, nature of the season, rotation and the like. The cultivator wishes to get the best return he can from the land at his disposal and will, therefore, put down the crop that is likely to pay him best under the conditions which obtain. India as a whole has not yet attained that development in matters agricultural which is brought about by increased facilities in transport and under which the major crops tend to become localised into the areas most suited for their production. The village, and even the family, is still, to a very great extent, a self-supporting unit.

Until such conditions are established, it is impossible to increase the cotton acreage directly in a fully settled country like the United Provinces. The present figure is the balance struck by the existing economic conditions. It may be possible in new tracts, such as the new canal colonies of the Punjab, to introduce, as condition of tenure, the growth of a certain area in cotton,* but no such method can be adopted in these Provinces.

* *Vide* recommendations of Deputation to Secretary of State for India, 1912.

Increased area here can only be brought about by increasing the value of the produce of a unit area. Thus the problem, especially as it applies to the United Provinces, is still further reduced to finding some method of increasing the value of the produce of a unit area, in other words, of increasing the money return to be derived from an acre of the crop.

Three methods suggest themselves, and they are—

1. To increase the quality of the product. Other things being equal, improved quality of the produce means a potentially more valuable crop ;

2. To increase the quantity or yield. This is the simplest and most direct, and with it is closely linked—

3. To increase the ginning outturn. The raw product, or kapas, gathered in the field consists of the two portions, lint and seed, of which the former is the more valuable. By increasing the ginning outturn, the percentage which this more valuable lint forms of the entire produce is increased and with it the money return from the crop as a whole.

Before we enter on a fuller discussion of these methods, a brief reference to further economic conditions must be made. Practically the entire crop in these Provinces is handled by middlemen in its passage from the cultivator to the consumer and it is with this middleman that the cultivator alone deals and to whom he looks for the immediate return for produce delivered. It is, therefore, the price this middleman is prepared to give, rather than the value of the produce to the consumer, which controls the growth of the crop. It is clearly of advantage for this agent to handle a single article in bulk rather than small quantities of different grades. It is for this reason that it is found so difficult to ensure the true value of the quality of the produce reaching the grower. Left to his own resources the cultivator has often to accept a price for his better produce which is less than that given for the inferior crop commonly grown. Of this we could give instances met with in our actual experience. We are here face to face with an economic force of no mean order which militates largely against dependence on

quality alone to bring about an increased money return per unit acre. Such forces are not readily surmounted and can only be met by an organisation of the buying agencies which will ensure the cultivator obtaining full value for quality. The difficulty is especially marked during the early stages of the introduction of types possessing a better quality of lint—that is, at the critical time when it is most desirable that the cultivator should appreciate the true value of his produce, he is least likely to obtain that value.

For our part, we are inclined to consider that such a radical change of method is likely to be slow. In our attempts to improve the value of a unit area, by an increase of quality we propose to subject all improved types to the critical test of a determination of their value at the current market rate of the local produce; in other words before such improved types pass from the experimental stage they must have proved themselves to be not inferior in yield, ginning percentage, et cetera, to those locally grown. The test is a severe one and may prove impracticable, but in this way only is it possible to ensure that the cultivator will not suffer.

We have shown that, under present conditions, the quality of the lint is of little value to the cultivator in the absence of special facilities for marketing his produce. There remain two points only which he can fully and directly appreciate, the yield and the ginning outturn, to which may be added to some extent the colour. With the yield he himself is alone concerned. For the second he is largely dependent on the purchaser. The ginning outturn is at the present time the controlling factor in the price paid for the produce, in that the purchaser is prepared to pay in nearly direct proportion to the figure at which the kapas gins. Thus he will pay Rs. 10 as. 10 per maund for kapas ginning out at 39% when he pays Rs. 9 as. 3 per maund* for *desi* kapas ginning out at 33%. In the ginning outturn, therefore, we have at once a most ready and most easily appreciated means of improvement.

* Values which have been obtained during the current season.

Before we leave the economic aspect of the subject, we may refer briefly to one further matter which intimately concerns the practical introduction of such improved types as are obtained. In the crop which covers over $1\frac{1}{4}$ million acres and which produces as much as 400,000 bales per annum a small percentage increase in yield, say 5%, is very perceptible. Owing very largely to the fact that the cotton crop is aggregated in the S. W. corner of the province—with its centre at Muttra—in which district some 30% of the kharif area is sown to cotton—the varying climatic conditions from year to year produce large fluctuations in the yield from the Province as a whole—larger than would be the case were the crop evenly distributed throughout when unfavourable conditions in one locality would be, in most seasons, compensated by favourable conditions in another. A 5% increase, such as we have presupposed, would be lost in the fluctuations which occur from season to season. It would become apparent only when comparative tests are conducted in the same locality and the error due to climatic variations thus eliminated. In practice, however, the relative value of two crops is not judged by such careful comparisons nor even by the returns of any wide area. The total area under the crop is divided into an infinitesimal number of small holdings, each under the ownership of a different cultivator who is very largely guided by his own personal experience. Under such conditions the variations caused by climatic conditions are extreme, and a 5% increase, such as we have presupposed, would become entirely masked. An increase, to be perceptible when judged under such conditions, must, we believe, be at least 20—25%. For this reason it is hard to convince the cultivator of the value of a particular type unless the increased return attains to some such figure as indicated. This argument, in the case of cotton, clearly applies to yield of kapas only. It does not apply to the ginning outturn which, therefore, forms the most salient point for attack in efforts at improvement.

We may now pass to a consideration of those aspects of the problem which are conditioned by the nature and habit of the

cotton plant and its interaction with its surroundings. Foremost among these we place the method of branching. This point has been dealt with in detail by one of us elsewhere.* Here it will suffice to say that on the nature of this branching depends the earliness or lateness of the flowering period and hence of the crop. The length of the vegetative period—that is, the time that elapses between the dates of sowing and of the appearance of the first flowers—will vary, according to the nature of the branching habit, from 55 to over 200 days. Now the climatic conditions under which cotton is grown in the United Provinces impose a very definite limit to the growing period. The cold weather, throughout the cotton tracts, is sufficiently intense not only to check growth but to kill the plant back. The plant must have flowered and fruited before this has well set in. Nor again is it possible to increase the vegetative period indefinitely by early sowing. Plants sown too early and exposed to the hot weather develop a stunted habit with precocious flowers. There is, therefore, also a marked anterior limit to the growing period. These limitations reduce the possible vegetative period to a maximum of 100 days. With types having a vegetative period of this length sowings will have to be made in May or early June, *i.e.*, before the monsoon sets in. Such types, therefore, require to be sown on irrigation and are suitable for irrigated tracts only. From the statistical returns it appears that of the $1\frac{1}{4}$ million acres, only $\frac{1}{4}$ million or some 20 per cent. are irrigated. Nor is the area irrigated equally distributed throughout; there are large tracts in which cotton is sown almost entirely on the rains. For these tracts such types are unsuited. The problem is, therefore, two-fold. An early flowering plant, which will yield a crop, even when sown on late rains, is required in addition to one suitable for growth on irrigation.

One further point on this aspect; it is useless to grow a plant which will fruit before the rains have well ceased. When such is the case the plant becomes exhausted in the production of bolls

* Journal of Genetics, Vol. 1, 3-1911.

which do not open or, if they do so, yield a very inferior and weak lint. There is, therefore, a definite limit, not only to the growing period, but also to the vegetative period. The ideal conditions for a full crop are found when the plant is in full boll and beginning to ripen its fruit shortly after the withdrawal of the monsoon. It is, therefore, as mistaken a practice to sow an early flowered type on irrigation as it is to sow a late flowered type on a late monsoon. The dual nature of the problem is thus very evident, it is not possible to evolve or obtain one type suited to the varying conditions of the Province. Owing, however, to the great fluctuations which occur from year to year in the date of arrival of the monsoon, the time for sowings on the rains is largely beyond control, and in some seasons it is possible to sow in this manner but a short time after the irrigated cotton has been sown. For this reason, and also owing to the considerable power which the plant possesses, of immediate response to external conditions, it is as inadvisable, as, for economic reasons, it is undesirable to plant irrigated and unirrigated areas of a single tract to different classes of cotton. The main cotton tracts are roughly divisible into two classes, for the one in which extended irrigation takes place, a late type, and for the other, characterised by little or no irrigation an early type, is desirable.

A second aspect is based on the observed occurrence of a large amount of cross-fertilisation. The method and extent of this have been dealt with in some detail in a former note.* The amount of cross-fertilisation which takes place during the cotton season in these provinces is there shown to be between 10 per cent. and 20 per cent. This means that 10 to 20 plants per hundred will be developed from seeds fertilized by pollen from a neighbouring plant. The amount is sufficient, when small areas of any type are grown in the proximity of other types, to lead to a complete loss of type in 4 or 5 years. The recognition of the practical bearings of this fact is most essential. They are twofold: (a) the necessity of introducing an improved type into, and throughout selected areas; (b) the desirability of establishing in the

* Memoirs. Dept. of Agriculture in India, Bot. Series, Vol. IV, No. 3.

improved type one or more distinct characters by which it can be differentiated at a glance from the mixture of types it replaces.

How far these varied conditions have been met may now be dealt with. They may be best explained under two heads—improvement by direct selection and improvement by breeding. The former, being the readier and yielding the quicker return, we take first.

Improvement by selection.—We have already stated that an improvement of the ginning outturn is a fact which appeals most readily to the cultivator in that the increased value of the produce is directly apparent in the increased price obtained for weight of kapas. It is here, as might be expected, that the largest practical results have been obtained. These results have so far been confined to the Aligarh district where one of us has isolated a type which gins out at slightly under 40 per cent. The lint of this type differs but slightly from the *desi* type which gins out at about 33 per cent. but the kapas sells at Rs. 10 as. 10 per maund against Rs. 9 as. 3 per maund* for *desi* kapas, an increase almost entirely due to the increased ginning outturn.

The plant is of a robust type with a moderately long vegetative period. It is characterised by a white flower and a deeply dissected leaf and is thus similar to the type recently developed in the Central Provinces.

A series of comparative trials between this white flowered type and the common yellow flowered type of the Aligarh district has given an average of 7 maunds 6 seers kapas for the former against 5 maunds 39 seers for the latter. Calculated on the above basis the improved type gives a money return of Rs. 76 against Rs. 54 as. 14 per acre—an increase of 40 per cent. The above outturns are for irrigated land only and it is probable the difference, when unirrigated land is also considered, would not be so great. We may safely count on a general average increase of 30 per cent.

We have here a type which fulfils the conditions we believe to be essential to the introduction of a new stock, namely, an

* See page 51 of this Journal, Vol. VIII.

increased money value of some 20—25 per cent. By its introduction, it may be hoped, not only to replace the *desi* mixture, but to increase the area under cotton in the localities where its introduction is attempted. It is lacking in certain desirable qualities it is true. Thus the lint shows but little improvement over the *desi* lint; * beyond its white flower which is also possessed by many types of *desi* plant, it has no very marked distinctive vegetative character by which it can be recognised in the vegetative condition.

This type is now being as widely distributed as circumstances will permit and the development is indicated in the following table :—

Area sown.		Acres.
1910-11	...	On experimental scale only.
1911-12	...	400
1912-13	...	1,500
1913-14	...	20,000 (estimated).

It has been recognised that this type does not attain to the ideal of what can be grown in these provinces and that it is merely one step towards that achievement. Therefore any organisation which is adopted should be one which will admit of the substitution of a still more improved type of plant than that at present under consideration, and we are inclined to think that that type will owe its value to an improved quality of the lint.

The recognition of this point has a vital bearing on the means adopted for distribution. The frequency of cross fertilisation has already been noted; and the effect of this, if allowed to take place between the local cottons and a type possessing a better quality of lint, will lead to a marked deterioration of the produce from the latter. The old adage that the strength of a chain lies in its weakest link applies here and the value of a sample of cotton is that of the shortest lint it contains. It follows that, to obtain the full advantage from improved quality,

* Superfine Bengals of the trade. Valued by the Imperial Institute (*vide* Impl. Inst. Bulletin, Vol. X, p. 363) it is worth $6\frac{3}{4}d.$ — $6\frac{3}{4}d.$ per lb., fine Bengals being $6\frac{1}{4}d.$ In Bombay it has been valued at Rs. 265 per candy with fine Bengals at Rs. 245.

It is necessary that that quality shall be uniform and hence that cross-fertilisation shall be prevented. In practice this means that the improved types should be grown in compact areas and not in isolated fields intermixed with fields of the ordinary types. Where quality is not a factor of importance such precautions are not necessary ; no amount of impurity affects the price of the lint while a small amount will not appreciably affect the yield. Having, therefore, hopes that improved quality will ultimately be attained, we have considered it advisable to develop an organisation which will readily admit of the introduction of types possessing quality under conditions which will avoid their reversion. As we have said, the main condition for this is the growth in compact areas. For this reason we have preferred to proceed cautiously and, in the extension of this type, to develop an organisation adapted to ready extension to other types having improved quality. For this purpose the village is taken as unit. Within this unit area efforts are made to get sown to the improved type an initial area which will be sufficient to supply seed enough to sow the entire cotton area in that unit in the following year. This initial area acts not only as a demonstration farm on a small scale but as a seed farm. In general it is found that cultivators are only too ready to take up a crop which they have seen grown with success in their immediate neighbourhood, and in a year or two it may be confidently anticipated that the improved type only will be grown throughout that area, which now forms not only a self-sufficient unit but one from which a supply of seed can be obtained for wider distribution in the same manner. Once this stage has been reached and the crop established throughout such a unit, that unit village can be left to arrange its own internal seed supply and the energies of the agricultural staff are released for development elsewhere. The seed handled by the department represents, therefore, only that which is used in expansion of the area ; those areas where the crop is established and which are merely inspected from time to time are not taken into account. Such seed as is recovered is distributed in areas where a serious effort is to be made to replace the *desi* crop

and, more scattered, through a wider area in small quantities; the latter being merely experimental with the object of ascertaining prospective areas suitable for further extension. The slow rate of increase in the earliest year (from 400—1,500 acres) is due to the fact that a comparatively large proportion of this area consisted of widely distributed small plots for the above purposes of demonstration, etc., and from these no attempt was made to recover the seed.

Present experience has already shown the difficulties which may be encountered in the development of such an organisation. Chief of these is the difficulty in buying back the seed in sufficient quantity. In the early stages of the introduction of a crop which is a distinct advance on that commonly grown, the demand for the produce is so keen, in the face of a limited supply, that the purchase of any quantity of seed becomes expensive. In the process, too, we are brought into contact in general not with a few reliable individuals but with a host of small growers many of whom have disposed of their crop before the produce is gathered, and who are, consequently, not free agents. Complete replacement, throughout a unit, of one type by another is, therefore, not the simple matter it appears. Progress must be slow especially at the first. It is to be hoped, however, that private assistance will be forthcoming eventually from the leading agriculturists of the tracts concerned, who can materially help by undertaking responsibility for the units in which they are particularly interested. Signs are not wanting that development will take place on these lines. Certain influential agriculturists already appreciate the value of growing such a type in compact areas and are prepared to organise the seed supply to this end. We aim, therefore, at replacing, as rapidly and as far as possible, the organisation outlined above, by one of private effort, in which the person possessing the greatest personal interest in the village unit undertakes the maintenance of the crop in a pure state throughout that unit.

A further selection has been made of a yellow flowered *desi* type which possesses a lint of improved quality. This does

not possess the high ginning outturn of the last but depends rather on the quality of its staple to give an increased money return per acre.

			Area sown (acres)
1912-13	...	...	30
1913-14	...	...	450 (estimated).

The organisation used in the distribution of this type is the same as that described above, but a different tract has been selected for its introduction.

Further selections have been made which are now in process of testing on the experimental farms. Of these we may mention two with a very early flowering habit, that is, with a vegetative period of 50—60 days only. These are—

(a) A white flowered *desi* plant, agreeing with Gammie's *G. neglectum* var *cutchica*,

(b) A yellow flowered plant having a naked seed.

The value of a naked seed for the production of cake is undoubted, and it is possible that such seed would fetch a higher price on this account and thus increase the money return per acre by increasing the value of what is, at present, the least valuable portion of the produce.

Both these types are suited to non-irrigated tracts, but they have so far not been tested sufficiently to be distributed to cultivators.

Improvement by Breeding.—This work has been developed especially at Cawnpore with the object of evolving a type which has, in addition to the qualities possessed by the *desi* types we have considered, a finer and more valuable lint.

The process is, as has been said, slower than the selective process and consequently practical results are hardly to be expected in the short period which has elapsed since the commencement. Nevertheless promise of ultimate success is not wanting.

Briefly stated, the method consists in isolating pure types which possess between them the more important desirable qualities; in crossing these and in isolating from the mixed

progeny a type which possesses the maximum of these qualities. For this purpose a series of types have been isolated and used as parents, including all *desi* types described above, which have been crossed with all the best cottons of India. Unfortunately neither the American nor Egyptian plant is available for this purpose since complete sterility exists between these and all *desi* types. For quality we are dependent on the true Indian cottons with fine lint and which we may summarise as follows :—

Broach cotton.—A plant which does not fruit till the subsequent hot weather and is, therefore, quite unsuited for cultivation in these Provinces.

Hinganghat cotton of the Central Provinces.—This is an early flowering type and has a low yield and a low (25%) ginning outturn.

Nurma cotton.—This is red flowered cotton grown round the temples in these Provinces and from its lint is spun the Brahmanical thread. It is a late flowered plant and yields no lint the first year. It is, however, grown as a perennial and, grown in this way, forms a large shrub. The plant appears now to be almost extinct and seed is with difficulty obtainable.

Crosses between these three types and several forms of *desi* plant have been effected. It has been found that when *Broach* cotton is used as a parent a considerable degree of sterility occurs in the offspring and on this account these crosses are not likely to be a practical success. In like manner when *Hinganghat* cotton is used as a parent the low yield of the progeny has proved the stumbling-block.

Matters are different, however, when *Nurma* is used as a parent and we have now a series of crosses between the *Nurma* plant and different types of *desi* plant which promise well. The characters of the *Nurma* plant may, therefore, be described more fully. In addition to the late flowering habit dependent on the type of branching, it possesses a red sap colour which declares itself not only in the deep red flowers but in the foliage, which is of a rich red tint. The lint is good, being slightly more than an inch in length, strong and somewhat silky. The ginning

outturn is low being some 26 per cent. only. When crossed with white or yellow flowered *desi* it gives a completely fertile plant which possesses the red colour of the *Nurma* parent. The intensity of the red, however, is definitely diminished, and it is thus easy to distinguish the cross from both its full red and from its colourless parent.

From this cross we have attempted to isolate a plant which possesses the early flowering habit, the high ginning outturn and the robustness and the yield of the *desi* parents and, in addition, the high quality of the *Nurma* lint. In addition we have attempted to obtain the red sap colour of the *Nurma* parent. After what has been said above concerning the advantage of a distinct character recognisable in the vegetative condition, the object of this will be obvious. The inspection of fields sown to such a type will be enormously facilitated. Before the first flowers appear, that is, before any danger of cross-fertilisation arises, the fields can be visited and, by a rapid inspection, it is possible to tell not only whether there has been any adulteration but whether the crop contains any appreciable admixture of rogues produced by chance cross-fertilisation in the previous year, and, in the latter case, the rogues can be removed during the ordinary process of thinning of the crop. No question of compensation, such as might arise when mature and bearing plants are removed, is incurred. The rogues will thus be removed before they can cause further injury to the standing crop. Without such distinctive characters, adulteration and rogues are with difficulty determined only by a careful examination of the lint, that is, after damage to the pure portion of the crop has occurred.

It is impossible to deal here with the large series of forms which have been isolated in the course of these experiments. We may say at once that the ideal combination of characters has not yet been obtained; but, what is more to the present purpose, there are clear indications that such a result is not unattainable. The chief difficulty in these experiments is to obtain a combination of quality with high ginning outturn—

quality alone is readily obtained—and until the conditions which determine this outturn are more fully understood the production of such a combination must remain a matter rather for chance. This question of the factors which determine the ginning outturn is now receiving detailed attention.

Of the results which have hitherto been obtained by such breeding we can mention a few only. Thus we have, growing on a $\frac{1}{8}$ acre scale, a type having the red foliage of the *Nurma* plant and a pink flower, with a vegetative period of about 100 days and a lint fully equal to that of the *Nurma* parent. The lint of this plant has been valued at $5\frac{1}{4}d.$ against $4d.$ for fine Bengals. A larger area must be grown before its capacity to produce a sufficiently heavy crop can be definitely ascertained but we have reason to believe that it will be deficient in this aspect in irrigated tracts. It is deficient in the ginning outturn which only reaches 30—32 per cent., and it may be that this will be sufficient to prevent its introduction on a practical scale.

A second type, similar to the last in leaf and flower colour, is also growing in a pure condition at Cawnpore. It gins out at about 35 per cent., but is somewhat deficient in quality when compared with the last, but much above the quality of fine Bengals. Its value would be about $5d.$ when fine Bengals are priced at $4d.$ It is a very early flowerer and would probably prove suited to non-irrigated tracts. Its yield cannot yet be calculated in figures but the individual plants appear most prolific.

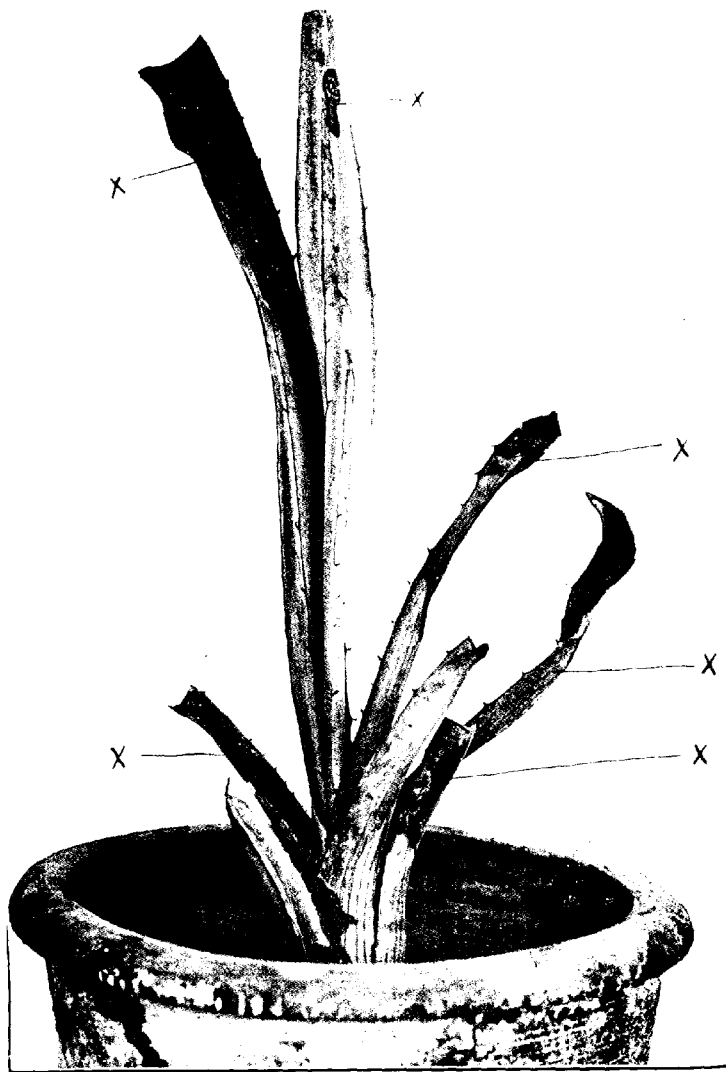
We now possess also a series of types not distinguishable from the *desi* cottons until the fruits open when the quality of the lint is at once apparent. The ginning outturn of these varies between 40 per cent. and 30 per cent., but in all cases further tests are required to establish their qualities as heavy yielders. This group as a whole, however, lack any distinctive vegetative character by which their control under field conditions will be simplified.

Two points remain to be considered in the process of multiplying these types up to the field scale. During this process it is necessary to reduce their number to a minimum by selection

based on their behaviour under field conditions and, secondly, it is necessary to maintain, at least for a few years, a centre of purity for the types finally selected for distribution. By a centre of purity is meant an area in which the crop is grown under such strict control that a pure seed supply will be guaranteed. This seed will be distributed to suitable centres and lead to a replacement of the crop in the same manner as is already being effected in the case of the white flowered cotton. The danger of deterioration, which has already been referred to when quality of lint is taken into consideration, requires additional precautions, and these are given by the establishment of such a centre of purity from which will issue annually a supply of pure seed tending to counteract the effects of admixture and cross-fertilisation. Such an area has already come into being in the establishment of a seed farm near Aligarh which will, as regards cotton, be used at first to subject the types now in process of evolution to critical tests in the field and later, it is to be hoped, to form such a centre of purity for the types ultimately selected during the early years of introduction.

We have attempted in the above note to describe not only the progress which has been made in the improvement of the indigenous cotton of these provinces, but the direction in which further progress is being attempted. Enough has been said to prove that the problem is no simple one and that the measures which have been adopted to produce a practical scheme, taking into consideration all the complex aspects of the problem, form a reasoned plan of campaign. How far success will be achieved the future alone can say, but whether we succeed or not in our ultimate aim of evolving and introducing into extended cultivation a plant having a greatly improved lint in addition to a high yield and high ginning outturn, we think that we can claim that at least some measure of practical success at improvement has already been achieved, and we hope that the experience gained in the process of breeding new types will not be found entirely unremunerative. Treated purely as a study in plant breeding the problem is highly intricate. We are now well acquainted

with the behaviour of the main vegetative characters of the plant, we know less concerning the behaviour of the fibre but sufficient to be able to obtain plants possessing a good quality of lint with ease. At the present stage, however, we know little concerning the factors which control the ginning outturn which, as we have shown, is a matter of vital importance if practical results are to be obtained. It is on the solution of this problem that we believe most to depend, until which time the production of types with high ginning outturns must remain a matter largely of chance.



A. J. I.

AGAVE PLANT INFECTED WITH COLLETOTRICHUM, DISEASED LEAVES MARKED X

ANTHRACNOSE OF SISAL HEMP.

BY

F. J. F. SHAW, B.Sc. (LOND.), A.R.C.S., F.L.S.

DURING the past eight years specimens of diseased *Agave* have been received in the Mycological Laboratory at irregular intervals. The diseased plants are invariably affected by a curious blackening and withering of the leaves, which usually begins at the apex and extends down towards the base of the leaf; sometimes, however, the blackened area is restricted to a small circular patch. The diseased portion of the leaf is shrunk, and thinner than the healthy, and, as a result, the cuticle is thrown up into ridges and furrows over the blackened area. In the more recently infected portions of the leaf, the colour is a light brown, which changes as the disease advances to deep black. In the final stages of the disease small erumpent nodules appear in concentric rings.

These symptoms are not at first accompanied by any very obvious signs of parasitic attack. This apparent absence of infection by external organisms, taken in conjunction with the nature of the symptoms, might lead one at first sight to suppose that the cause of the disease was to be sought rather in defective cultivation and adverse climatic conditions than in the attack of any fungal parasite. In German East Africa a disease of Sisal Hemp, which closely resembles that described above, is the cause of considerable loss in the fibre plantations. Braun* states definitely that the disease is due to excessive insolation. He was able to produce the characteristic symptoms

* Braun, K. — Blatflecken an Sisalagaven in Deutsch-Ostafrika. *Berichte über Land- und Forstwirtschaft in Deutsch-Ostafrika*. Dritter Band, Heft 4. 1908.

of the disease by placing healthy leaves under a high temperature in the laboratory. As a temperature, which under artificial conditions is sufficient to cause disease, occurs frequently in German East Africa, it seemed probable that the source of the trouble had been discovered.

While it is not disputed that excessive insolation, especially when the rays of the sun are concentrated through drops of water, may produce burnt and discoloured patches in the leaf, yet the results of the present research show that the disease which occurs in India is due to the attack of a parasitic fungus.

In 1892 Cavara* described a fungus, which he named *Colletotrichum Agaves*, occurring on the leaves of species of *Agave* in Lombardy. A description and illustration of this fungus is included by Montemartini† in his monograph of the *Melanconiaceæ*. In 1903 Dr. E. J. Butler‡ noted the association of *Colletotrichum Agaves* Cav. with a disease of *Agave rigida* var. *Sisalana*; it was not, however, established that the fungus was the cause of the disease. Two years later a disease of cultivated *Agave* due to the attack of *Colletotrichum Agaves* Cav. occurred in the Missouri Botanic Gardens. Hedgcock§ who investigated the fungus at the Missouri Botanic Gardens, made some inoculations with the mycelium and succeeded in producing the disease in healthy plants. He does not mention any other fungus as occurring in association with the *Colletotrichum*, a fact which is of interest, as in Guatemala, Kellerman|| found a species of *Plowrightia* associated with *Colletotrichum Agaves* on *Agave americana*. The symptoms of the disease were very similar to those described above, acervuli or fructifications of *Colletotrichum* were developed on the diseased tissue in concentric rings.

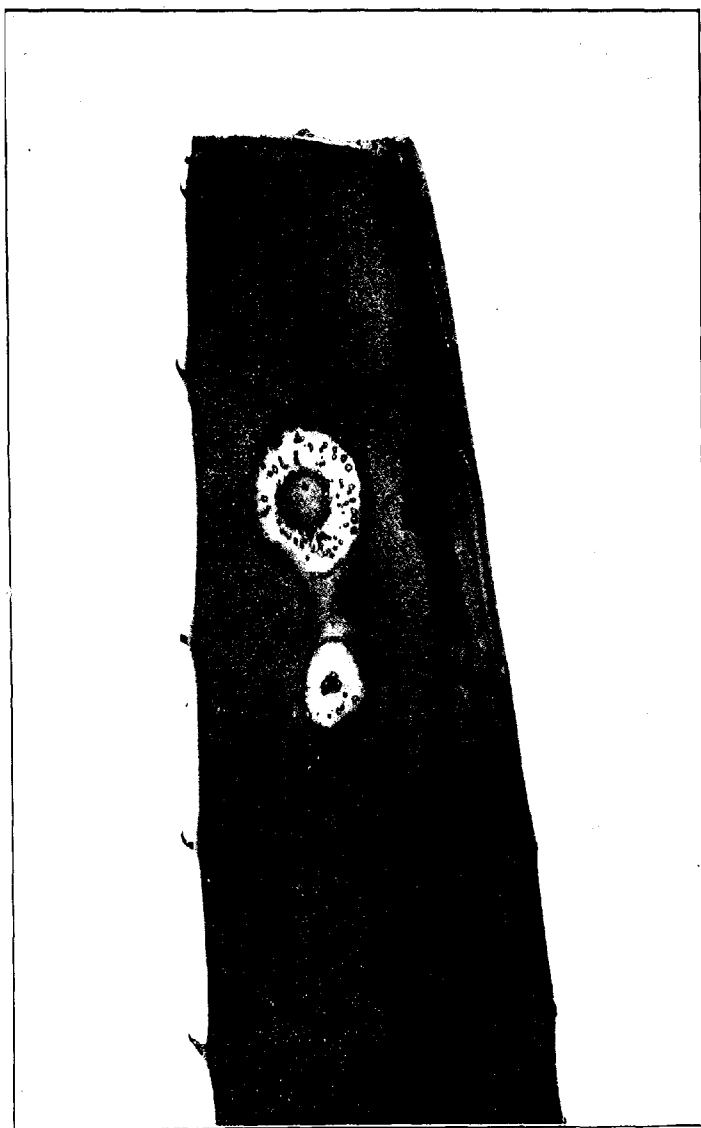
* Cavara, F.—*Hedwigia* XXXI, 1892, p. 315.

† Montemartini, L.—*Ricerche sopra la struttura delle Melanconieæ*. *Atti Istit. Bot. Pavia*, VI, 1900, Tab. 12, fig. 10.

‡ Butler, E. J.—*Pilzkrankheiten in Indien im Jahre 1903*. *Zeitschrift für Pflanzenkrankheiten*, Bd. XV, p. 44.

§ Hedgcock, G.—*Disease of cultivated Agaves due to Colletotrichum*, Report Missouri Bot. Gard., 1905.

|| Kellerman, W. A.—*A new Plowrightia from Guatemala*. *Journal of Mycology* XII, 1906



A. J. L.

LEAF OF AGAVE INFECTED WITH *C. AGAVES*, SHOWING DEVELOPMENT OF
ACERVULI IN CONCENTRIC RINGS.

Sisal Hemp infected with *Colletotrichum* has been obtained from a number of Districts including South Sylhet, Cachar, Assam, Cawnpore and Dacca. In spite, however, of the general occurrence of this fungus on diseased Agave it was not at first believed that *Colletotrichum* could cause such extensive and serious damage. The arrival of a fresh parcel of diseased leaves from Dacca gave a favourable opportunity for obtaining pure culture of the fungus. Acervuli were cut out from the diseased leaves, and, after having been first washed in sterile water, were placed in agar tubes. Other portions of diseased leaves were flamed in alcohol and incubated in sterile petri dishes. In both cases a white mycelial growth was obtained, which, on sub-culturing on agar, gave rise to a typical culture of *Colletotrichum*. Hedgcock seems to have had some difficulty in obtaining spores in agar cultures; in our cultures, however, there was an abundant formation of acervuli.

Inoculations were made on small specimens of Agave growing in pots. In the first series of infections the leaves were wounded by making a small cut, tangential to the surface, and a minute piece of agar culture was inserted into the wound. The first result of infection is a blackening of the tissue at the immediate seat of infection. From now onwards the disease follows one of two courses according as the host plant succumbs easily or resists the attack. In the first case the whole leaf turns yellow, the change in colour spreading out from the seat of infection (Plate XVI). As the disease advances, the yellow colour changes to black and small black acervuli of *Colletotrichum* are produced; in most cases the acervuli are distributed in concentric rings. The whole leaf eventually becomes shrunken and dry, the cuticle being thrown into a series of ridges and furrows. If the host plant resists the attack of the fungus the progress of the disease is much slower. In this case the damage is confined to the portion of the leaf immediately around the seat of infection (Plate XVII). In this small area the tissues become black and shrunken, so that an irregular depression arises on both surfaces of the leaf. Acervuli are produced in concentric rings, as in

the more extensively diseased specimens. A section through the diseased leaf shows hyphæ of *Colletotrichum* ramifying in all directions through the tissues. If the section includes a fructification the hyphæ are seen to collect and form a thick mass of pseudoparenchyma at the base of the acervulum (Plate XVII). From this pseudoparenchyma the hyphæ grow upwards in a brush-like tuft, and finally, burst out through the ruptured epidermis as a mass of conidiophores bearing spores. In those cases in which the diseased portion of the leaf is restricted to a small area surrounding the seat of infection, a section through the junction of diseased and healthy tissue shows a layer of cork cells across which the hyphæ do not penetrate.

Other infections were made in which pieces of agar culture were laid upon the uninjured upper surface of the leaf; none of these were successful. It looks therefore as if *Colletotrichum Agaves* was a wound parasite requiring some damage to the host plant before it can produce infection. Nor indeed, when we remember the thick cuticle of *Agave*, is there anything surprising in the inability of the fungus to penetrate the uninjured surface. It is not unusual to find longitudinal cracks in the leaves of *Agave*, especially after a period of hot dry weather, such breaks in the superficial tissues would afford a ready means of infection from air-borne spores. Collecting and burning diseased leaves and spraying with Bordeaux Mixture are methods which should prove efficacious in checking the disease.



A. J. I.

SECTION THROUGH LEAF OF AGAVE SHOWING ACERVULUS OF
C. AGAVES.

PRELIMINARY NOTE ON THE OCCURRENCE OF ACIDITY IN HIGHLAND SOILS.

BY

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Agri. Chemist to the Government of Bengal,

AND

A. G. BIRT, B. SC.,

Dy. Director of Agriculture, Assam.

OUR attention was drawn to the occurrence of well marked acidity in highland soil both at Dacca on the stiff red old alluvium, and at Jorhat where the soil is still old alluvium but more sandy, when considering the infertility of these soils, which is most marked during the cold weather.

The possibility of the existence of a high degree of acidity in such highland and often well drained soils, is one which up to now has perhaps not received the attention it deserves in those tracts in India where conditions climatic, etc., generally might be supposed to tend to soil acidification. The common idea that an injurious degree of acidity is confined to low-lying marshy or peaty soils is wholly erroneous, as our work on some highland and quite well drained soils proves.

We have reason to believe that the occurrence of such a degree of acidity as is positively injurious to many cultivated crops is far more widespread in N.-E. India than may be commonly supposed.

This might be explained on the grounds that these soils may have been originally formed from rocks more or less deficient in basic ingredients; and that the amounts of lime, etc., present in these soils originally, have been subjected to gradual but certain diminution, by removals in drainage water

in a region of heavy rainfall, and by the constant withdrawal in crops of basic ash ingredients which exist as neutral salts in the soil.

The preferential leaching of lime is well known; when this process has gone far enough to establish a certain degree of acidity the conditions set up favour the increased removal in drainage water of other plant foods notably phosphoric acid, so it comes about that acid soils are generally more or less deficient in phosphoric acid, and respond to its suitable application.

Most cultivated crops prefer a neutral or very faintly alkaline soil, but it so happens that some crops are more tolerant of acidity than others, that is to say, when grown in an acid soil they make fair or even good growth while others either succumb or make very poor stunted unhealthy growth.

The fact that some crops do well on acid soil is no proof that they therefore prefer it to a neutral or faintly alkaline one, or that they would not do better on the latter kind of soil; it is a question of competition in nature, and it is simply because they have a greater, and other plants a less tolerance towards acidity, that the latter succumb and the former are given an undisputed field, hence in many cases giving rise to erroneous conclusions.

It is possibly this fact which has tended to divert attention from the undoubted evils that soil acidity exercises in the case of many cultivated crops, and has probably caused the failure of certain crops, and not of others, on this class of land to be ascribed to other than the true cause, failures being attributed to lack or excess of moisture, bad germination, fungus attacks, etc., in ignorance of the real reason underlying it. This happened early on in our own experience at Jorhat when an entire failure of the oat crop on land which produces fair crops of *Aus* paddy, and which before sowing the oats had a good dressing of cowdung, led us to suspect lack of soil moisture as the cause.

Examination proved that this was not the case. The seeds germinated perfectly and grew to a few inches in height

then suddenly turned yellow and died out. The top 6 inches of soil was in quite good physical condition and there was plenty of moisture within 2 inches of the surface, and conditions for aeration are in this soil first class.

A crop of *mati-kalai* sown at the same time not only germinated but gave poor to fair crops. In view of all these considerations we were driven to seek another cause and found it was located in the acid condition of the soil. Analysis showed a deficiency of basic ingredients to which the accumulation of compounds toxic to the plant may be attributed, and as a further result of which soil acidity accrues. It does not follow that the toxic compounds are themselves acid, yet it appears probable that in view of the remarkable action of lime on these soils the toxins are either acids or acid compounds, and moreover they are probably only formed or at least able to accumulate to a dangerous degree in soils very deficient in carbonate of lime.

Recent work, not yet completed, has disclosed the presence in these soils of an organic compound acid in character, definitely toxic to certain seedling plants, but the noxious character of which in such cases is minimised or entirely negatived by addition of lime to neutrality. This laboratory work agrees entirely with field observations and fixes the characteristic infertility of these soils, with respect to certain cropping, as due, largely to a definitely toxic organic compound, acid in character, the evil effects of which may be largely, if not entirely, overcome by the use of lime.

It is well known that lime brings about many changes of a chemical, physical and biological character in soils; most soils contain sufficient lime to supply the food requirements of crops for this substance, and we have figures which prove that one of its least actions on our soils is as a direct source of plant food. We are convinced also that comparatively little of its action is to be ascribed to physical changes, at any rate at Jorhat.

That it induces very much improved biological conditions is evident in the very much healthier tone and darker green colour of crops which follow its application. Probably its greatest function is the establishment of sound healthy soil

conditions by its action on the noxious acid compounds present. It is highly improbable that nitrification is entirely suspended on these acid soils, yet it is possibly so far reduced that plants cannot obtain, in the form of nitrates, all the nitrogen which they require, hence those crops which depend for their nitrogen supplies chiefly on nitrates suffer more from an acid soil condition than others which have the power of drawing upon other combinations of nitrogen to a greater extent.

Our early experience with oats, previous to the sowing of which a heavy dressing of cowdung was given, but no lime, and which still failed to produce any crop, proves that acid soils are entirely uneconomical of manuring; it is in agreement with universal experience that the most economical soils are those which are neutral or faintly alkaline.

It is highly probable, considering the nature of these soil toxins, that deep cultivation and thorough aeration combined with the growth and incorporation of green crops will tend to improve matters, but it will take much time compared with the rapid action of lime, and moreover on many soils the addition of some lime would seem to be almost a necessity to secure even a decent green crop for turning in.

Our experiments up-to-date tend to show that the neutralising effect of lime dressings is not exerted to any great extent below the depth to which it is mixed with the soil during the ordinary process of cultivation. That this is true may be gathered also from Rothamsted experience; during the 18th century and earlier repeated "chalking" with chalk rock drawn from 10 to 12 feet below the surface, was practised there. To-day, it is stated that lime carbonate is only found in the surface soil. Moreover, judging from the cropping to date, our results indicate that for most common field and garden crops, it is not even desirable that the acidity should be neutralised to any very great depth, but that if the soil be limed sufficiently to render the cultivated depth very faintly alkaline, so far as immediately succeeding crops are concerned, it is not only needless, but possibly occasionally harmful, to apply more lime than will ensure this.

Though the applied lime may subsequently not be found to any great extent except in the surface soil and to ordinary cultivation depth, still this does not preclude its action extending further down, because the passage of soluble bicarbonate of lime downwards during drainage can still bring about flocculation, precipitation and other changes in its path, and this constant leaching of bi-carbonate is a well known phenomenon ; laboratory proof of such action on the sub-soil is already in our possession. The deeper the cultivation, of course, the more lime will be needed to neutralise the acidity, because the added lime will thereby be spread over a larger volume of soil.

While our results so far thus show that it is probably better practice and more economical of lime to apply only such quantities as will render the soil faintly alkaline to the ordinary cultivation depth, they also prove that to apply any less quantity than will ensure this, is not enough to produce full crops, and that though lime be applied in smaller quantities at intervals, ultimately the soil must be rendered faintly alkaline to the depth of cultivation practised. Lime should be intimately mixed with the soil as soon as possible after application ; otherwise its full early effect will not follow, and a dangerous degree of local alkalinity may be set up.

For ordinary agricultural practice it should, we think, be kept fairly near the surface. The amount of lime which it is safe or advisable to use depends, of course, on a number of other considerations besides the degree of acidity, and the depth of cultivation commonly practised ; such factors as the cropping to be followed, and the continued use of certain artificials, *e.g.*, sulphate of ammonia have also to be considered.

Our work in connection with the lime problem is being extended to include other phases of its use than those briefly touched on above.

For the present, it is enough to point out the fact that acidity does occur in highland soils, in some cases where one perhaps might not expect to meet it, and, to enforce the recognition of the great value of lime as an ameliorating agent.

RING BUDDING.

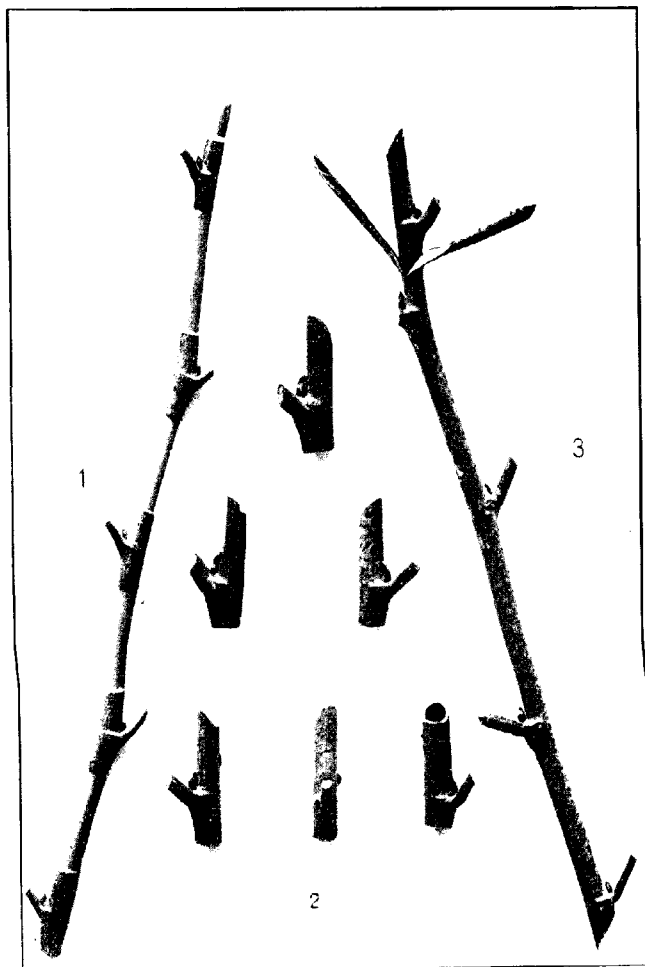
BY

MOHD. AMIN KHAN, L.A.G.,

Farm Manager, Peshawar Agricultural Station.

IN the neighbourhood of Agra, Delhi, Lahore and other large cities in Northern India where fruits are extensively grown, there are groups of expert budding men who are employed by nurserymen as each budding season comes round. Many fruit growers bud their own plants, and peach-growers frequently combine nursery work with fruit-growing. "Chhala" or "ring budding" is the method invariably practised in the propagation of peaches and pears, but some apricots, plums and mulberries are also ring budded. The art of ring-budding is extremely simple, and in India this is certainly the most expeditious and satisfactory method of propagating the fruits named above. The budding of peaches only will now be followed in detail, and the methods of work which are practised at the Peshawar Agricultural Station will be described. The table on page 77 outlines the propagation treatment which other deciduous fruits require.

Preparation of Stocks.—In early November, the land which has been fallowed for some months in preparation for peaches is finally ploughed, levelled and plotted into canal squares. On 15th November, the area is marked in straight rows $2\frac{1}{2}$ feet apart, and drills 3 inches in depth are cut out by the Planet Junior Hand Hoe. The peach stones are planted about 8 inches apart in the lines, and are covered by working soil by the feet into the drills. It is advisable to insert a pin of wood at either end of each line in order to guide workmen



A. J. I

RING BUDDING.

when they are hoeing between the rows, until the seedlings appear above ground. Irrigation will probably be necessary on two or three occasions before the seeds germinate in February, and hoeing is especially advantageous after irrigation. By the 15th May, the seedlings will be 12 or 18 inches in height, erect, full of vigour and ready to receive ring buds.

Budding.—Vigorous shoots 18 inches or more in length, with bark of a slightly rosy hue, and which have been cut from the crown of a healthy fruiting tree provide the best buds. Vegetative growth should not have finished in the shoots: these should be firm but not ripe. In Plate XIX, the method of taking off and placing buds is very clearly shown. The shoot at (1) has its leaves trimmed off fairly close to their buds, and rings of bark have been removed. If the sap is in condition, the internodal rings of bark will be easily removed and the exposed surface of the wood of the shoot will have a slippery, sticky feeling. With the ball of the thumb and the forefinger of the right hand, the ring buds are successively slipped off the shoot by a dexterous pull and outward twist of the fingers. It is not generally the custom to ring the length of the shoot as shown in Plate at 1. More frequently the internodal rings are removed as each bud is slipped off, working from the apex to the base of the shoot. At (2) various aspects of very perfect fistular buds are shown. No. 3 shows a peach shoot with a ring bud correctly superimposed. The bark of the shoot which has been budded has been slipped back and downwards until the ring bud firmly fitted the skinned shoot. The spare point of the shoot has been cut away above the bud. Something has been sacrificed for the sake of the picture at (3) where the bud is placed on a side shoot, and not on the main stem of a young peach seedling, as it should be. Guided by one who has practised the art, ring budding can be learned in a few moments. At the Peshawar Agricultural Station the budding is done by the farm labourers. An expert budder, under favourable circumstances, can bud from 200 to 400 plants per day of 8 hours, and he expects 90 to 95 per cent. of

his buds to grow if bright, hot and calm weather prevails for some days after budding. Dull days, with wind and low temperature, are unfavourable to successful ring budding; dewy cold nights just after budding occasionally cause some failures.

Irrigation and Cultivation.—The plots are necessarily rather dry when budding is being performed, so water must be given immediately after the operation, and the soil should afterwards be kept moist until the buds are growing freely. Within ten days of budding, the buds should begin to show signs of growth, and when they are $\frac{1}{2}$ an inch in length the side shoots of the seedling foster-parents must be in part removed in order to conserve the vigour of the seedling in the growing scions. As the buds grow upwards, so must the shoots of the fostering stocks be gradually trimmed off. By the time the scions are 3 inches in length, the side shoots of the foster-parents should be entirely removed. Plate XX shows a ring budded peach plant at six weeks of age, which has been budded too high for general purposes, probably because budding had been delayed until the seedling foster-parent was rather tall. Nursery treatment after the sixth week consists chiefly in encouraging vigorous growth by frequent hoeing and by timely but not over free irrigation. By early November, a good ring budded peach plant is 4 to 5 feet in height and furnished with a useful foundation of side branches. It is fit to set out in the orchard within twelve months of the sowing of the seed of its foster-parent. In its second year in the orchard, it bears a few peaches; in its third year, it should carry a paying crop of between 40 to 60 lbs. of fruits. On Plate XXI an orchard of ring budded peaches is shown. It was planted in December and January 1910-11 after the plants had an extra year in the nursery. At Peshawar Agricultural Station, the Planet Junior Hand Hoe is kept moving in the nursery lines, and the bullock hoe works between the orchard rows. Vegetables of many kinds are grown between the peaches during the first and second year in the life of the peach orchard.

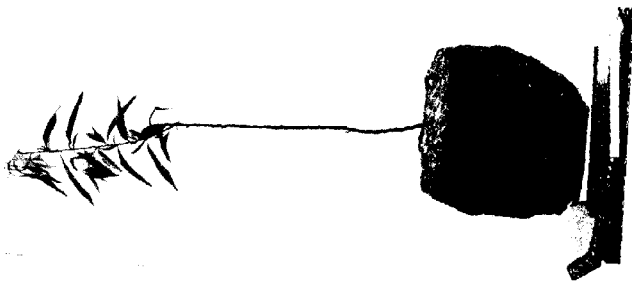
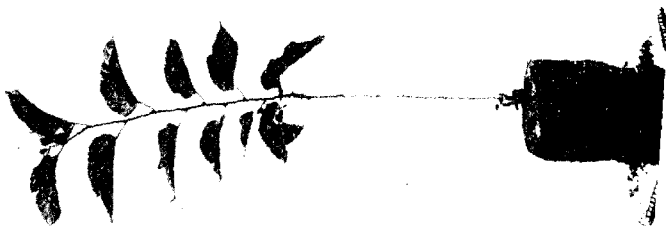
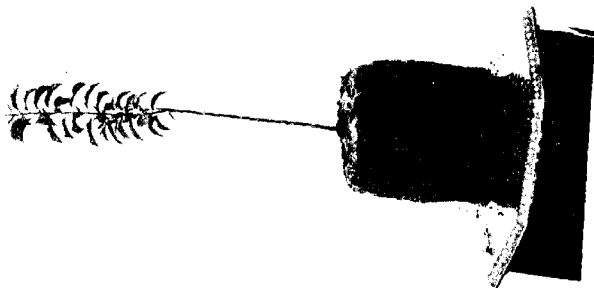
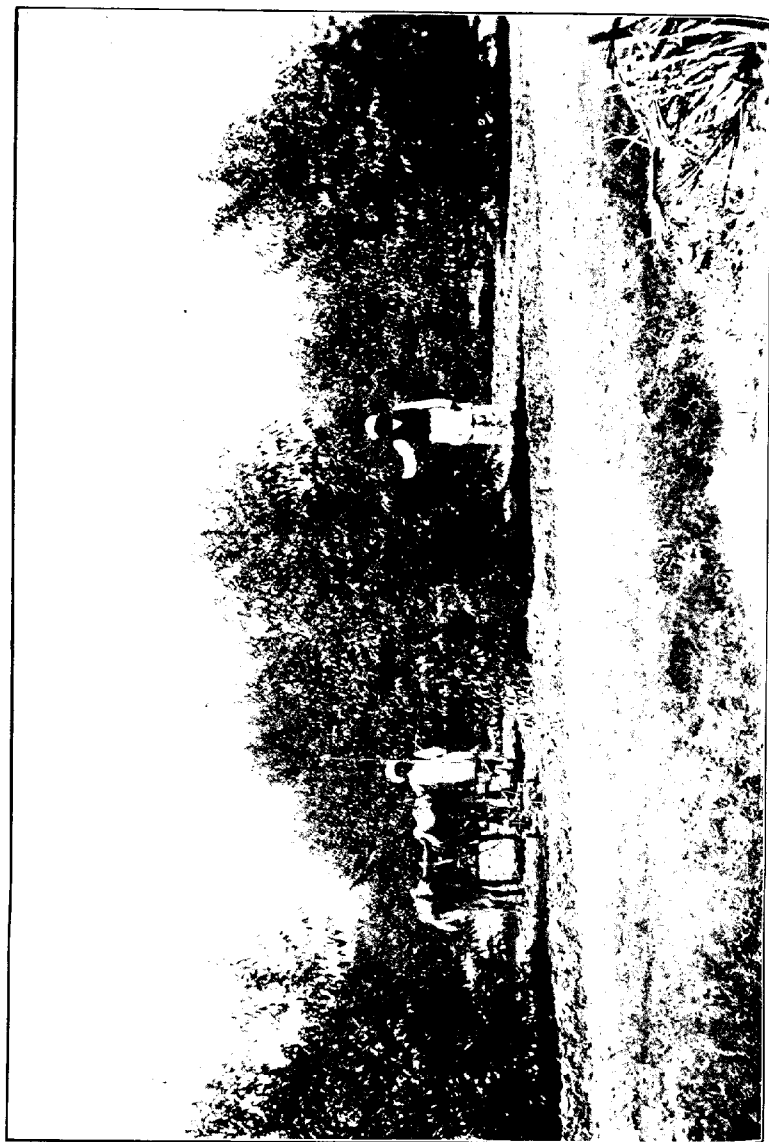


PLATE XXI.



RING BUDDING TABLE.

Fruit.	Stock.	Date of Planting stock.	Date of budding.	Date of Orchard planting.	REMARKS.
Peach ...	Seedling Peach ...	Stones on 15th November.	15th May to 15th June.	15th December to 15th January.	
Plum	{ Seedling Plum } Seedling Peach }	Stones on 15th November.	} Do.	Do.	For Sandy soil bud on Peach. For heavy soil, use plum stock.
	{ Plum Cutting ... }	15th December			
Apricot ...	Seedling Apricot...	Stones on 15th November.	Do	Do.	
Pear	{ Wild Pear } "Pyraus Pashia" }	Suckers on 1st to 15th December.	} Do.	Do.	The wild pear for big pear trees: quince for dwarf trees.
	{ Quince } "Cydonia v u l - garis." }	Cuttings 1st to 15th December.			
Mulberry {	{ Wild Mulberry } "Moris indica." }	Cuttings on 1st to 15th December.	} Do.	Do.	

NOTES.

THE STEEL MEMORIAL MEDAL.—At a meeting of the Council of the Royal College of Veterinary Surgeons, held at 10, Red Lion Square, on Friday, October 11th, it was unanimously decided that the Steel Memorial Medal be awarded to Major J. D. E. Holmes, M.A., D.Sc., M.R.C.V.S., of the Indian Civil Veterinary Department. The medal, established to perpetuate the name of John Henry Steel, is one of the highest honours the profession can bestow and is always awarded for original research in matters pertaining to the profession.

(The Veterinary Journal, London, November 1912.)

* * *

CO-OPERATIVE CATTLE INSURANCE SOCIETIES.—The subject of Co-operative Cattle Insurance Societies is somewhat akin to that of rural Co-operative Credit Societies in conjunction with which they might be most efficiently worked in India. One great drawback to the poorer class of cultivators keeping good cows is the risk of their death, and if by the payment of a small sum per annum this loss could be recouped to them it would go some way at least perhaps in solving two vital questions of the day, *viz.*, the rise in price of plough bullocks and the rise in price of milk, ghee and other milk products.

Before considering the question from an Indian point of view it will be useful to see what is being done in England among small holders in this connection, and statistics have been lately compiled relating to the 22 registered co-operative societies in England and Wales up to the end of the year 1910, partic-

ulars not being available of unregistered societies of a similar character. The 22 societies had a total membership of 1,631 members varying in numbers from 14 to 331 members, giving an average of 74 members per society. The number of cows and calves insured was 4,588, varying in number from 14 to 1,329, giving an average of 209 per society. Yearly premiums are in most cases about 4/- for cows, the amount payable at death averaging about £10, the premium thus being about 2% of the sum insured. Some societies fix a maximum of £9, £12 or £14 per cow, others pay $\frac{3}{4}$ to $\frac{4}{5}$ of the value without limit, others pay £12, £10, or £8 according as the premium paid is 6/-, 5/-, or 4/-. For calves the yearly premium is generally 3/- after the age of 6 months, the amount payable at death being about £5.

All societies have a rule by which a special levy up to 1s. per animal insured may be raised in the event of funds being insufficient to meet the claims during the year, but this is very seldom necessary as most of the societies have accumulated a considerable surplus from which a possible deficit can be met. In addition to the premiums it is usual to charge an entrance fee, the commonest rate being 6d., 1/- or 1/6 per cow and 6d. or 9d. per calf. The proceeds of the hide and carcases valued at about £1 per animal are also credited to the society. The number of animals that died during 1910 averaged 2.2 per cent., during 1911 it was 2.6 per cent., varying from 3.8 per cent. to nil in the various societies.

The members of these societies are mostly small holders, the average number of animals insured being only 2.8 per member and rules are in force in most societies limiting the number of animals which any one member may insure. The societies are managed by a committee, two or three trustees, one or more Stewards, a secretary and a treasurer, the chief responsibility devolving upon the Stewards whose duty it is to pass and brand the animals offered for insurance, to visit sick animals, etc. For these services they usually receive a small fee from the owner, of from 2d. to 6d. per animal for branding and 1/- or 1/6 for attendance on sickness or at death. Other rules include the punishment by fine

or expulsion for neglect of cattle or for attempting to raise disaffection among members of the society.

As examples of the 22 societies we will take (1) the oldest, that of Mawdesley in Lancashire established in 1807 with 33 members, which insures 53 cows at a premium of 6/- per annum, pays £10 on each cow at death, and has a premium income of £19-10 and a surplus fund of £46; (2) the largest, that of Whixall in Salop, established in 1842, with 307 members, which insures 1,329 cows and calves at an average premium of 3/10, pays an average sum of £7-12-6 per animal at death and has a premium income of £254-2-0 and a surplus fund of £1,176.

The large insurance societies dealing in live-stock insurance charge a premium of $7\frac{1}{2}\%$ or say 5/- on a cow valued at £10 as compared with 4/- in the co-operative societies, the death-rate of cows insured with them averaging about 6% as against about 2% in the co-operative societies. The difference in death rate is accounted for by the more individual care given to their animals by small holders and the less likelihood of having unsound animals admitted to insurance. The difference in rate of premium not accounted for by the increased death-rate is due partly to the Insurance Companies having to put aside nearly 40% of their premium income for expenses of management, agency and veterinary fees, etc.

With regard to the conditions suitable for such a society in India, premiums should of necessity be strictly based on the estimated value of the animal, perhaps 6 pies per rupee equivalent to $3\frac{1}{8}\%$ per cent. would be about the correct percentage for cows and calves, and 9 pies per rupee or $4\frac{9}{16}\%$ for working bullocks. The *Stewards*, who should be responsible and expert members of the committee should value the animals and the premium should be levied on the sum payable in event of death, which should be not more than $\frac{3}{4}$ ths of the estimated value. A small *entrance fee* and also a fee for attendance when sick or at death should be levied at the rate of 4 or 8 annas per animal.

In the same way as the committee of the co-operative credit societies may refuse admittance of any person to the society who,

they think, is not to be depended upon, so the committee of the Cattle Insurance Society would refuse insurance to those who had a reputation for underfeeding or overworking their cattle. It is obvious that in tracts of the country where a scarcity of rain brings a fodder famine such societies could not work, but these tracts are now becoming smaller and smaller owing to the means provided for obtaining grass by rail from long distances. A trial might at least be made in canal-irrigated and sub-montane tracts and parts of the country like Bengal, where there is always enough fodder.

Enquiries have been made from the Registrars of Co-operative Societies of the various Provinces and they report that nothing has yet been done in connection with Cattle Insurance except that in one or two cases the idea has been mentioned at public meetings of those interested as a possible extension of the work.

Since writing the above, I learn from the Registrar of Co-operative Credit Societies in Burma that 23 Cattle Insurance Societies have been formed there, and that they are progressing and working successfully.

From a copy of the byelaws kindly sent to me by the Registrar I find the following are the most important conditions :—

General. (1) The Society insures only healthy bullocks and male and female buffaloes between the ages of 4 and 12 years.

(2) No indemnity is paid in the case of loss from rinderpest or from any contagious disease mentioned in the Veterinary Rules (when the owner has not complied with the rules), riot, theft, straying or railway journey.

Valuation. (3) A member must declare *all* his plough cattle, giving their age, value and description : these will be checked by experts and fixed for insurance.

Premium. (4) A premium of 3 per cent. must be paid in advance in six-monthly instalments.

Deaths. (5) On the death of an insured animal the owner must report the death to, and get it vouched for by, at least two

members or one expert : he will then report to the Committee, who will arrange for the sale of the skin and flesh.

Payment of Indemnity. (6) The Society will pay two-thirds of the insured value of the animal, after deducting the sale proceeds of the skin and flesh, payments being made at the next half-yearly meeting.

Insufficient Funds. (7) If funds are insufficient, the Reserve Fund may be drawn on up to half of its total amount : if funds are still insufficient, indemnities must be proportionately reduced for all deaths during the year.

Reserve Fund. (8) The Reserve Fund shall be formed from (1) fines for non-attendance at meetings, (2) entrance fees which may be levied from new members after the first year, (3) donations, (4) the yearly excess amount of receipts over expenditure and interest on reserve funds.

Veterinary Attendance. (9) If the Committee think that Veterinary attendance is necessary the cost will be paid half by the Society and half by the owner.

Management. (10) The Society shall be managed by the Committee, who shall appoint a Chairman, who shall also be a Treasurer, Vice-Chairman and Secretary, who will give their services gratuitously.

General Meetings. (11) General Meetings shall be held on August 1st and February 1st, at which all business shall be openly transacted ; all members must attend under penalty of a fine of Re. 1.

It is estimated that deaths from other causes than those enumerated in para. 2 will not exceed $5\frac{1}{3}\%$.

Taking a Society insuring 120 cattle worth an average of Rs. 45 each, the annual premium will be $3\frac{1}{3}\%$ of 120×45 = Rs. 162.

Assuming that 6 animals die during the year and that the proceeds of their carcasses average Rs. 8, the net loss to owners is $(6 \times \text{Rs. } 45 - 6 \times \text{Rs. } 8) = \text{Rs. } 270$ minus Rs. 48 = Rs. 222 of which the two-thirds part payable by the Society is Rs. 148.

PLATE XXII

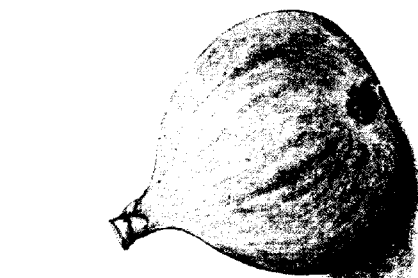
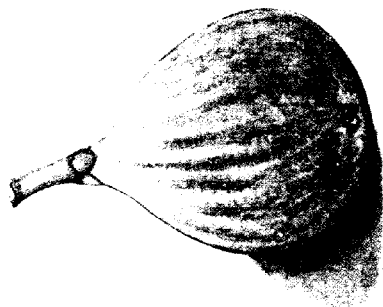
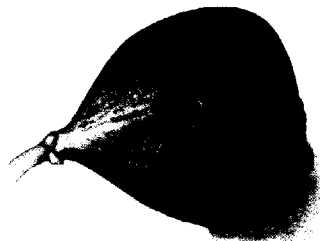


Fig. 2



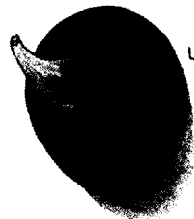
3



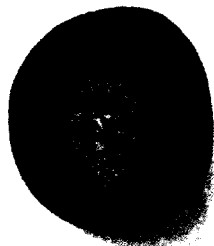
4



6



5



7

W. H. R. 100

There remains a balance of Rs. 14 to be credited to the Reserve Fund.

Burma having made a successful beginning with these Societies, the time seems to have arrived for Registrars of Co-operative Credit Societies, and others interested in the welfare of the people to take the matter up.—(A. W. FREMANTLE.)

* * *

EXPERIMENTAL FIG DRYING AT SASWAD.—After hearing a complaint from fig cultivators in the village of Saswad, Poona District, that their figs fetch no price after one shower has fallen in June, the writer thought of undertaking an experiment in drying figs locally. Every year big consignments of dried figs are received in Bombay from Turkestan, Smyrna, Greece and other parts, and they are sold at the rate of eight to ten annas a pound.

The writer put up with a cultivator at Amboni, a village near Saswad, and began the experiment in his plantation. The owner was kind enough to allow work in his plot and he also granted the concession of bagging and plucking the fruits at any time. The greatest difficulty about this fruit is that all do not ripen at one and the same time; nor is it allowed to remain on the plants until it is completely ripe, on account of the trouble from beasts and birds, so only half ripe fruits are collected and sent to the market (see Figs. 2 and 3, Plate XXII).

An attempt was made to collect a few seers a day of more developed fruits (see Fig. 4). Still one could not get that degree of ripeness which is recommended in the literature on this process. About 4 seers (38 figs) in all were got the first time and these were dried on a bamboo mat. Every second hour they were turned upside down. In the evening they were brought into the room and again in the morning at 9 A.M. they were exposed. The temperature varied from 91° to 95° F. at 3 P.M., and at 8 A.M. from 81° to 83° F. Again the next day some three seers were added to the lot. The first lot gradually began to contract after three to four days (see Fig. 5), when they were lightly pressed as found in the market. Severe pressing made some fruits burst

and consequently rot (see Fig. 6), so careful handling and pressing was then done. Completely ripe fruits did not yield to the heavy pressing, but only those that were half ripe (see Figs. 2 and 3). In about ten days the first lot became ready for further treatment. This was assured when the fruits did not sink any longer and yielded to the pressure without the least resistance (see Fig. 7). They were weighed and found to be scarcely a seer. In the meanwhile the second lot was gathered. The fruits of the first lot were washed in boiling salt water, the strength being $1\frac{1}{2}$ lbs. to 50 gallons of water or .3 per cent., and then dried in the sun. After drying it was found that the weight lost was 75 per cent. One seer fresh figs gave one-quarter of a seer of dried figs.

From the above it will be seen that the drying of this fruit, if carefully done, is likely to solve to some extent the difficulty of fig cultivators in the Poona district.--(L. B. KULKARNI.)

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USEFUL MEASUREMENTS FOR LAYING OUT PLOTS.—In laying out an Experiment Farm it is usually necessary to arrange for a number of small plots on which to compare varieties of crops of which only a little seed is available. It is frequently not advisable to make the boundaries of these small plots permanent because of the difficulties in cultivating small areas and because later on it may be desirable to experiment on larger plots. At the same time it is necessary to have a certain number of permanent boundaries such as watercourses and farm roads.

For the United Provinces we have worked out an area of a size convenient for ploughing, which can be divided into small rectangular plots and which can also be divided without much waste of land into larger areas of a convenient shape.

180 feet \times 242 feet = one acre.

A plot of 180 feet wide can be easily divided into temporary $\frac{1}{9}$ th of an acre by leaving a middle road of 4 feet. That gives 88 feet on each side and 88 feet \times 55 feet = $\frac{1}{9}$ th acre.

A plot of land 180 feet wide and 983 feet long allows of sub-division into thirty-four $\frac{1}{9}$ ths of an acre as follows. Run a 4-foot road up the middle. This gives 17 plots on each side.

$$\begin{array}{rcl} 17 \times 55 & & = 935 \\ 16 \text{ temporary roads of } 3 \text{ feet each} & = & 48 \\ \hline & & 983 \text{ feet.} \end{array}$$

A plot 983 feet long can also be conveniently divided into four acres as follows:—

$$\begin{array}{rcl} 242 \text{ feet} \times 4 & & = 968 \text{ feet.} \\ 3 \text{ roads of } 5 \text{ feet each} & = & 15 \text{ feet.} \\ \hline & & 983 \text{ feet.} \end{array}$$

Similarly $(13 \times 55) + (12 \times 3) = 751$
 751 gives six half acres thus:—
 $(6 \times 121) + (5 \times 5)$.

Another useful number is 635.

$$\begin{array}{rcl} (11 \times 55) + (10 \times 3) & & = 635 \\ (5 \times 121) + (4 \times 7' 6'') & & = 635 \end{array}$$

(A. E. PARR and H. M. LEAKE.)

* *

FEEDING FOR BUTTER-FAT.—In his article on the General Feeding Characteristics of different classes of stock which forms Part II of the series of articles on the feeding of farm stock, contributed to the Journal of the Board of Agriculture (London), Dr. Crowther of Leeds University discusses what influence feeding has upon the richness of milk. He says:—

“The percentage composition of the milk yielded by a particular animal is largely independent of the nature of the food supplied. Provided that the ration is such that it maintains the milk-yield and general “condition” of the animal, the composition of the milk can in general be but little affected by changes in the nature of the foods included in the ration. Even

in the case of under-feeding the composition of the milk is, as a rule, but little affected until the condition of the animal has been very seriously reduced. Little reliance can be placed, therefore, upon the claims advanced on behalf of certain foods that they exercise a specific influence upon the composition of the milk. The commonest of such foods are malt coombs, palm-nut cake, and cocoanut cake—all of which are said to exercise a specific beneficial effect upon the quality of the milk. There is good evidence that this is true to a *limited extent* of the two cakes mentioned.

“A further exception ought perhaps to be made of the case of very watery foods, such as turnips or brewers’ grains, in view of the widespread opinion of farmers and cowkeepers that the quality of cow’s milk can be appreciably lowered by the use of such foods. This view has received as yet but little support from the experimental investigation of the subject, which, however, needs to be considerably amplified before the question can be regarded as definitely settled. Long-continued consumption of excessively watery food will probably lead ultimately to a general weakening of the organs of the body and thereby cause a secretion of more watery milk. As a rule, however, the amount of water supplied in the food can vary greatly without diluting the milk. Certainly under ordinary conditions the quantity of milk secreted is quite independent of the amount of water consumed by the animal, the excess, if any, being mainly excreted in the urine and through the skin.

“Although the nature of the food has, in general, little effect upon the percentage composition of the milk, it may have an appreciable effect upon the quality of the milk in other ways, *e.g.*, flavour, hardness of butter-fat and so forth. This fact must be kept in mind in selecting food-stuffs for the ration of cows.”

Ability to yield rich milk seems to be an inherited character, and if more butter-fat is to be got from any cow, it can only be done by feeding to get a greater yield of milk of the same

quality. But there is a limit beyond which no higher yield of milk can be obtained by increasing the food-supply as there is an increasing tendency for additional food to promote fattening rather than to increase the flow of milk. This limit varies greatly in different individuals of the same class.—(EDITOR.)

* *

SEPARATED MILK.—Cream separators are now seen working in many big cities of India. They make a large quantity of separated milk available for use. It is, therefore, desirable that the feeding value of this milk should be known. Separated milk contains about 3.15 per cent. of casein which forms about 80% of the total proteid matter of milk and being a nutritious substance, the separated milk remains a valuable article of diet. Separated milk also contains mineral matter and when fed to animals helps in bone formation. Though it contains the whole of the protein of the milk, it is nearly devoid of the fat which should be otherwise supplied. It is employed in the preparation of bread, biscuits, cakes, and sweetmeats. It can be used for calf feeding. The deficient ingredient in separated milk as stated above is fat and to make a perfect calf food some carbohydrate must be added in a form easily digestible by the young animal.—(EDITOR.)

* *

IN the course of his article on the feeding of farm stock Dr. Crowther of Leeds University says that in selecting the concentrated foods for dairy cows due regard must be paid to their possible influence upon the flavour of the milk, or more particularly the flavour, appearance, and texture of the butter. The following food-stuffs, if used liberally, have a softening tendency upon the butter-fat—rice-meal, maize, oats, wheat bran. On the other hand, a hardening influence is exercised by beans, peas, cotton cakes and meals, and coconut cake. These effects are only appreciable when the food-stuffs in question are used liberally, and may be avoided by using appropriate mixtures of foods.

Musty, mouldy, or otherwise damaged food should be avoided as far as possible, as objectionable taints may easily be imparted to the milk. So far as the influence of the food upon the flavour of the milk and butter is concerned, good pasturage stands unrivalled, carrots are probably the best of the root crops, oats the best of the cereal grains, and rice-meal or maize germ meal the best of the cereal offals.

* *

SUGAR FROM MAIZE.—A paper on the above subject by Mr. G. N. Blackshaw, Agricultural Chemist to the Government of Rhodesia, appears in the *Rhodesian Agricultural Journal* for October 1912. It seems that a factory for manufacturing sugar from maize was established in France about 1850 and large quantities were actually made, but the project failed owing to the development of sugar beet.

More recently Mr. F. L. Stewart, in Pennsylvania, has shown that removing the cobs from the stalks when in the "milk" stage, results in an accumulation of sugar in the stem, and he has advocated the manufacture of sugar, alcohol, and cellulose simultaneously—involving the utilisation of the whole plant, stalk, leaf and ear.

Mr. Blackshaw has, therefore, conducted experiments devised to determine the sugar content of varieties of maize grown in Rhodesia and the effect of removing the cobs. His analyses show a great variation in the sugar content of the stems of different varieties when the cobs were allowed to mature, but the differences are reduced by the removal of the cobs, which, the experiment shows, caused a rapid concentration of sugar in the stem during the first week after removal, culminating about the sixth week,—apparently at the same time that the cobs on the rest of the crop matured.

The percentage of sugar in the juice of the decobbed stalks cut at this time varied between $12\frac{1}{2}$ and 14, and the glucose between .9 and 1.1 per cent. The amount of solids not sugar in the juice was generally over 3 per cent. The maximum quantity

of sucrose extracted by the mill used, was 7 per cent. of the weight of the stalk. These results do not appear discouraging when the great variability of the maize plant and its adaptability to development in different directions by selection are taken into account. If successive crops of maize could be utilised in cane sugar factories, it would mean a valuable extension of the season.

Analyses made by Dr. Leather at Pusa in 1911 showed that the proportion of sucrose to weight of stem may rise as high as 9 per cent. in Indian maize, but this represents that recoverable by chemical extraction, not by crushing.

It is probable that in India's shorter season the concentration of sugar would culminate more rapidly, and as to this the time of maturity of the cobs on the main crop should be some guide to experimenters.—(A. C. DOBBS.)

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FLEAS ON HORSES.—The study of Medical and Veterinary Entomology is so constantly bringing to light new relationships between diseases and insects that it is becoming increasingly important to collect every scrap of evidence regarding the occurrence of these latter, and biting insects of all sorts should be collected wherever possible. Whilst on my way to Kollegal in July last I noticed that a *jutka*-pony at Maddur (in Mysore) was infested with large fleas which literally swarmed all over the upper part of its head and neck. As the host seemed to be an unusual subject for the attack of fleas, specimens were collected and have been determined as the Dog Flea (*Ctenocephalus canis*) by the Hon. N. C. Rothschild. So far as I know, this flea has not previously been known to attack horses, so that the record becomes of interest. Neveu-Lemaire ("Parasitologie des Animaux domestiques") states that the Human Flea (*Pulex irritans*) may occasionally attack horses, but otherwise these animals seem remarkably free from flea-attack, so far at least as the *Pulicinae* are concerned; several species of *Sarcopsyllinae*, however, are known to attack them.—(T. BAINBRIGGE FLETCHER.)

THE FEEDING OF COCONUT CAKE TO MILCH COWS.—(JOUR. South-Eastern Agric. Coll. Wye, No. 20, 1911, Mr. S. Skelton.) An investigation was carried out on the College Farm during the months of April and May, 1911, to determine the suitability of coconut cake as a food for the production of milk and butter. Three cows, which had calved about two months previously, were selected, and, after being fed for a fortnight on an ordinary ration, were given a diet containing coconut cake, the quantity fed being at first 2lbs. a day and gradually increased to 6lbs. per head daily. The total period in which the coconut cake was fed was three weeks, after which the cows were kept under observation for a week, during which time they received ordinary foods. The coconut cake appeared to produce very little effect on the yield and quality of the milk, and on the Reichert number of the butter, though in view of the shortness of the period and the small number of cows it is impossible to draw definite conclusions. It was clear, however, that the cake made the butter much firmer, and it is suggested that on this account it should prove useful as a food in warm weather when difficulty is experienced in making firm butter. (From the Journal of the Board of Agriculture Vol. XIX, No. 7, October, 1912.)

* * *

THE FLOWERING OF THE MANGO.—Referring to a note by Mr. Tamhankar, that appeared in Part IV, Vol. VII of this Journal, Mr. Hartless, Superintendent of the Botanical Gardens at Saharanpur, has sent us a note of his experience with regard to the flowering of the mango, from which the following is taken:—

“The flowering of the mango is a subject to which I have given some attention for the last two years especially; particularly with regard to those under cultivation in these gardens, where we have nearly 100 varieties.

There is no disputing the fact that there are a few varieties that are irregular in their flowering period, the cause of which it is difficult to ascertain. I have known such abnormality in the ordinary Bombay even, due to a local injury in the first

instance and perpetuated to some extent. But I have not been able to test if this periodicity was hereditary or not.

The variety Baramashi has, as its name implies, the reputation of fruiting all the year round, but here in Northern India, it rarely fruits more than twice a year, the controlling influence being undoubtedly climate.

Personally I have never heard of any *variety* that flowers normally every year. Most *trees* will flower every year more or less, the amount depending on the condition of the trees, and the extent of their productivity the preceding year. If we can get *varieties* with this fixed character of normally flowering every year, we shall solve what is at present a great drawback in mango cultivation.

The real test is to see if the character is hereditary or not. I am of the opinion that it is not, and that a change of climate and environment would show the instability of this character.

Out of nearly 60 varieties observed in 1911, the difference between the earliest and the last to commence to flower was only 25 days. The earliest to commence to flower in 1912 was what we call Bombay Dr. King, meaning that it was received from Dr. King when he was Superintendent of the Royal Botanic Gardens, Calcutta. This commenced to flower on the 20th of February. The latest to commence to flower was Kachmahua, which it did on March 20th.

The first six varieties to flower were :—

Bombay Green,	Bombay Dr. King,	Bulbulchashni,
Davies' Favourite,	Nayab,	Singapuri.

The last six to commence to flower were :—

Hathijhul,	Kachmahua,	Moradabadi,
Nucka,	Pyasee,	Sharbati Brown.

It is interesting to compare the average time that these plants remained in flower.

For the first six (earliest) the average duration of flowering was 30 days.

For the second lot of six varieties (latest) the average was only 12 days, showing a difference of 18 days in the flowering

period of those which flower early in the season and those which flower later. The inferred cause is the increase in the temperature for the period of the year.

In the year 1911, which was a bad year, owing to untimely rain spoiling the flowers or preventing pollination, the averages were 17 and 9 respectively for the six earliest and the six latest to flower, showing a difference of 8 days.

For 1912, the average flowering duration for 58 varieties was 16 days, whereas that for 33 varieties observed in 1911 was only 11 days. As in the latter year the flowering period was most probably shortened by rain at the time, the figures for 1912 may be taken as more nearly correct.

It may here be remarked that the year 1910 was what may be called a "lean" year, and the natural inference was that 1911 would be a "fat" year, but owing to rain at the time of flowering spoiling pollination, it was one of the worst on record. Then, in 1912 the mango crop was one of the largest ever known, following two bad years, one of which was due to what we may call an inherited habit and the other to injury. This should tend to prove the contention that alternation in bearing is primarily due to over-production, with a consequent exhaustion, followed by recoupment. It may not be out of place now to give some further analysis of Mango flowers, that I have made this last season, and which may also possibly serve as a basis for classification.

The points taken into consideration were :—

- (a) Colour of the flowers.
- (b) Colour of the flower stalk.
- (c) Length of the panicle.

(a) and (b) have been divided into the predominant colours, and (c) according to the length of the panicle,—short equal to 4"—8", medium equal to 8"—16" and long 16"—20" long. The varieties are arranged in tables under the respective characters. These tables are given in the hope that other investigators will take the matter up. In this way we may hope ultimately to find a more stable basis for classification than that suggested in the note on this subject that appeared in the last issue of this journal."

MANGOES.

[illegible]

Short	equal to	4"-8"
Medium	"	8"-16"
Long	"	16"-20"

REVIEWS.

Die Züchtung der landwirtschaftlichen Kulturpflanzen, Volume V (Paul Parey, Berlin, 1912).—The increased activity during recent years in the improvement of crops, which has followed the rediscovery of Mendel's law, has shown the necessity of a new type of handbook. Investigations dealing with such problems require information of a kind which is not to be found in the usual works of reference. For example, in studying a new crop, the first problem which confronts the plant-breeder is the difficulty of classifying and subdividing the existing varieties so as to obtain pure material as a starting point for his investigations. The varietal differences involved are so small that the information to be obtained from even the most detailed flora is of little or no use. The plant-breeder's classification only begins where that of the systematist ends. In a similar manner, the information required on everything which concerns the flower must be much more precise and definite than that necessary to the ordinary botanist. The smallest details concerned with the floral mechanism and with the periods at which the anthers and stigma ripen may be of immense importance both in actual hybridization work and also in considering the possibility of maintaining an improved variety. This publication, of which the fifth volume is now under review, was designed to supply this want. The first four volumes deal with the agricultural crops of Europe and contain a concise and clear account of all that is known concerning the varietal characters of these crops and their constancy, the floral mechanism and biology of the flower, the frequency of cross and self-fertilisation as well as a short account of the results obtained up to the present by hybridization

and by the various methods of selection. In many cases, practical details are given of the methods and technique which have been successfully adopted in hybridizing and in selecting the particular crop under discussion. References are also given to all the important literature.

Some of the most widely cultivated Indian crops such as wheat, maize and tobacco have already been dealt with in the earlier volumes on account of their position in European agriculture. The present volume, No. V, deals with tropical and subtropical plants only and includes most of the remaining Indian crops of importance such as sugarcane, rice, cotton, coffee and many others. Professor Dr. Fruwirth, the editor and author of the largest portion of the first four volumes, is also the editor of Volume V, but, in this case, owing to the distribution of the crops described, a large number of other authors have participated. In nearly all cases each crop has been dealt with by an investigator who is himself concerned with the improvement of that crop; for instance, the chapter on the improvement of sugarcane has been contributed by Van der Stok, the Director of the Java Sugar Experiment Station. This adds very materially to the value of the information and also gives the book a vividness and a wealth of practical detail which could be obtained in no other way. Attention may be drawn to the articles on sugarcane and rice, the first by Van der Stok and the second by Fruwirth and Van der Stok, which are both excellent. These articles together with that on cotton by Leake are by far the most comprehensive, and show that in these three crops a great deal of progress has been made. The number and value of the chapters emanating from the Dutch Colonies, namely, the articles on rice, sugarcane, cacao, coffee, cassava and ground-nuts, reflect the great attention which has been devoted to the improvement of crops in their tropical possessions by the Government of the Netherlands. In many cases the information available on the crops dealt with in this volume is still scanty, but it is hoped that this will be remedied in later editions and that new chapters on other crops will be

added. The publication of the book will in itself stimulate research and draw the attention of workers to those portions of the subject on which the existing information is most meagre. In India, where so much attention is now being paid to the improvement of crops and where it is not always possible to obtain all the literature required, such a book will prove invaluable and will be of the greatest assistance to all engaged in plant-breeding.—(G. L. C. H.)

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DIE FAUNA DER DEUTSCHEN KOLONIEN. REIHE V. HEFT. 4; DIE SCHÄDLINGE DER BAUMWOLLE. VON DR. G. AULMANN, BERLIN, 1912. Price, 5 marks.

PRECEDING parts of this publication have been noticed in these pages (Vol. VII, page 411). The fourth and latest part, consisting of 166 pages illustrated by 120 text-figures, is devoted to the insect-pests of the cotton-plant in the various German Colonies. Many of these pests are very widely spread throughout the Tropics and some thirty of those mentioned in this pamphlet are to be found in India either as identical or closely-allied species, but this number, it may be added, includes many which are only destructive to cotton-seed. The account of each insect includes references to economic literature, description of the insect, geographical distribution, life history and damage done, and remedial measures.—(T. B. F.)

* * *

PUBLICATIONS OF PROVINCIAL AGRICULTURAL DEPARTMENTS.

Bombay.—The second part of a bulletin on the *Seed Supply of the Ahmednagar District* by Mr. G. D. Mehta, deals principally with the seeds of kharif crops. On the whole, the cultivators in this district appear to select the best seed for sowing purposes and to preserve it well, though the cleaning leaves much to be desired. Cotton seed, however, which is always bought from shopkeepers, is usually very inferior, and the author insists on the necessity of establishing some kind of enlightened control over the supply of seed of this important staple.

A bulletin by Mr. Burns and Mr. Patwardhan on *The Treatment of Grape-vine Mildew* completes a series on this subject. It has been found that careful pruning, removal of old bark and periodic spraying with Bordeaux mixture and soap are most successful in preventing the attack of mildew.

* *

Mr. G. N. Sahasrabudhe who has spent two years in the West Indies studying sugar manufacture, is the author of an interesting bulletin on *Muscovado Sugar Machinery*.

He advocates the adoption of the Muscovado process for the manufacture of *gur* in India, in factories costing from Rs. 70,000 to Rs. 1,00,000 to erect and capable of dealing with 10,000 to 12,000 tons of cane in the season. A good *prima facie* case is made out for considering the establishment of such factories likely to be profitable, and details of the cost, working expenses, and probable receipts are given, purporting to shew that with *gur* at Rs. 120 per ton and a sufficient supply of cane within a four-mile radius, such a factory would earn from 40 to 60 per cent. on the capital invested.

* *

Bengal.—The April number of the *Quarterly Journal* issued by the Bengal Department appears somewhat late.

In the principal article Dr. Jenkins gives an account of some "Observations on the shallow water Fauna of the Bay of Bengal made on the Bengal Fisheries Steam-trawler, *Golden Crown*, 1908-1909."

There are notes by Mr. Woodhouse and Mr. Ghosh on the flowering of sugar-cane in Bengal and on cross pollination and variation in Italian Millet (*Setaria italica*); and by Mr. Smith on the results of seed selection on the yield of maize at Kalimpong.

A short note by Mr. B. Palchoudhuri contains some remarkable statements in connection with the introduction by him during the last 10 years of Australian (Shorthorn and Ayrshire) bulls among ordinary Bengal cattle. These bulls roam about

according to the custom of the country and remain in good condition. The cross-bred bullocks appear to be highly appreciated for draught purposes, beating the Bengal bullocks "hollow, in drawing the cart or plough."

The cross-bred cows, when properly fed and cared for, have given up to 9 seers of milk a day, but their chief recommendation is that they continue milking for a much longer time than the ordinary Bengal cow. On the other hand, the cross-breeds are more delicate than the ordinary cattle and require better feeding.

* *

Assam.—The Assam Department of Agriculture has published in the form of a bulletin a *Note on Manures* contributed by Mr. Meggitt to the discussion of that subject at the meeting of the Board of Agriculture in 1911. The results, detailed in the bulletin, of experiments in Assam, appear to justify Mr. Meggitt in his conclusions that the greatest promise lies in the better use of the indigenous organic manures—cowdung, oilcake, and bones, and in the extension of green manuring.

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Madras.—A similar note by Mr. Harrison on *The Indigenous Manures of Southern India and their Application* is published by the Madras Department. Price 6 pies.

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Central Provinces.—Corresponding information for the Central Provinces is given in a note by Mr. Clouston in the October number of the *Agricultural and Co-operative Gazette* published under the orders of the Director of Agriculture and the Registrar of Co-operative Societies, Central Provinces and Berar.

The September number of this Gazette is a particularly good one and contains among other articles one by the Commissioner of Berar in which he suggests that members of the District Agricultural and Industrial Associations should form semi-philanthropic companies for the growth under expert supervision, and for the sale of seed of improved cotton; an undertaking

which has been proved on the Akola Government Farm to be exceedingly profitable. Figures are given, founded on the experience obtained at Akola, which shew that a profit of 11 per cent. on the capital invested, might be expected; and it is suggested that if the members of such companies would agree to be satisfied with, say, 6 per cent., the remainder might be used in popularising other agricultural improvements. In consideration, apparently, of such a self-denying ordinance, the Central Provinces Administration would endeavour to find trained men to take charge of such farms.

In a series of suggestive notes in the same number, the Registrar of Co-operative Societies lays down some of the principles which should guide the issue of loans to members of Societies in the Central Provinces, and leads up to a set of "Draft byelaws for a Co-operative Insurance Society for Plough Cattle" which should form a useful basis upon which to draw up the articles of other similar Associations in India.

* *

The *Quarterly Journal of the Indian Tea Association* contains, among others, a note by Dr. Hope on a method of renovating old tea bushes by pruning, and articles by the same author on the value of Leguminous Trees in tea gardens and on the use of artificial and chemical manures.

* *

A leaflet entitled *Hints on Grafting*, issued by the Bombay Department of Agriculture, contains short instructions on grafting, with simple clear illustrations and should be useful to anyone who is unable to obtain skilled assistance, in multiplying good varieties of fruit trees. —(A. C. D.)

PUBLICATIONS OF THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA.

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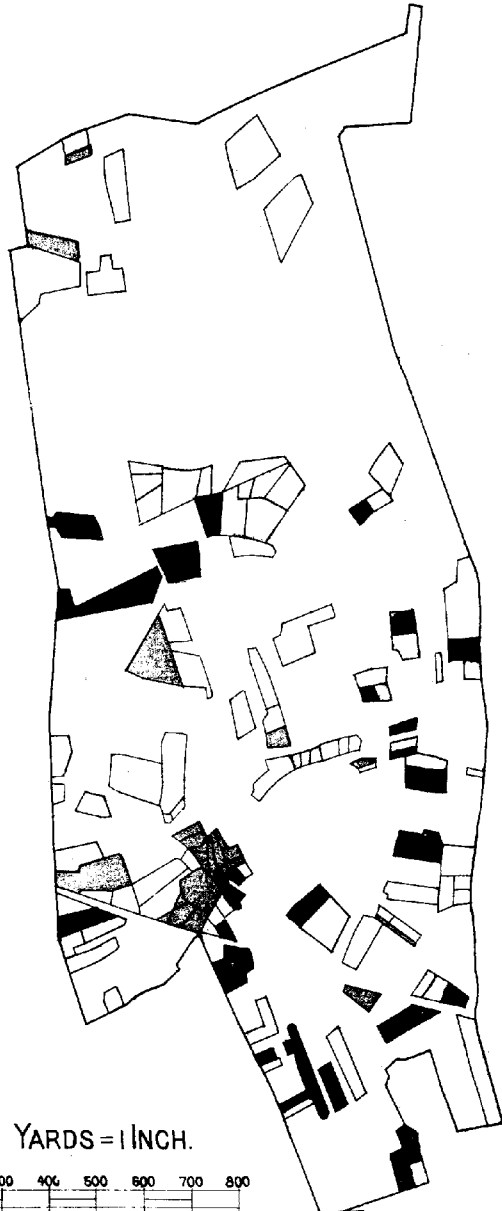
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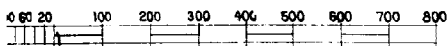
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SCALE 320 YARDS = 1 INCH.



Map showing the scattered nature of five individual holdings in the Hoshiarpur District, Punjab.

The areas of the holdings are respectively :—

				<i>Acres.</i>
Black	...	...	...	15.55
Yellow	...	...	...	27.83
Brown	...	...	...	9.48
Pink	...	...	...	11.25
Green	...	...	...	10.01

THE. CONSOLIDATION OF SCATTERED HOLDINGS.

THE evils of scattered agricultural holdings in India and the desirability of employing official agency to consolidate such holdings have been recently urged by Raja Pyari Mohan Mukharjee, President of the Swadeshi Mela, in his speech made by him at Calcutta on the occasion of the opening ceremony of the Mela on 14th September 1912. The Raja is reported to have said as follows :—

“The most formidable obstacle in the way of agricultural reform is the smallness of ryotty holdings. In several districts the number of ryots holding less than an acre of land is legion, while the holdings of others which vary from five to ten acres or more, comprise a number of plots situated as often as not in different fields at distances of several hundreds of yards from one another. Such a state of things involves great loss of time and labour, it renders all economic arrangement for drainage and irrigation of land quite impossible, and it involves the ryots in endless disputes regarding ingress and egress of water to and from neighbouring plots. The evil becomes much greater when the holding is further divided and sub-divided by the operation of the laws of inheritance, and two or more co-sharers have a joint tenancy in each of the small plots which originally belonged to a common ancestor. These evils have been remedied in Japan by converting all small holdings into compact farms by exchange, addition and deduction of lands held by different tenants and creating a number of peasant proprietors, the farms and areas of whose lands are controlled by an Agricultural Bureau appointed by the State.”

Though this, so far as we are aware, is the first public utterance in favour of official intervention, the evil in question, both as regards tenants and as regards small proprietors, has long been recognised in India. In those mines of interesting information, the Appendices to the Famine Commission Report of 1880, will be found a paper by Sir Charles Elliot and Sir Edward Buck in which these well-known authorities wrote as follows :—

“It is an evil from an agricultural point of view that the land of each holder should be broken up and separated (for, even if the proprietor does not cultivate himself, he has to give his tenants broken holdings), and it would be a great advantage to distribute cultivators' holdings as far as possible by blocks.”

The Japanese practice was brought to notice in an article by Mr. Shearer in this Journal in January 1908, and the issue of October 1912 contained a note on the corresponding practice in Austria. Mr. Keatinge also, the late Director of Agriculture in Bombay, in Chapter III of his recent work on the "Rural Economy of the Bombay Deccan," and in his lecture delivered to the Society of Arts on the 16th January 1913, regarding "Agricultural progress in Western India," has examined the characteristics of the "economic holding," and has recognised the economic loss due to holdings being scattered in different portions of a village. Most persons acquainted with rural India must be aware of cases in which the scattered character of holdings has been the cause of much loss and discontent, but hitherto there has been, so far as we are aware, no definite scheme put forward for Government interference in the matter.

Indian students of agricultural economy, when looking outside India, have usually turned their eyes to England, which of all countries in the world affords the most unsuitable basis for comparison with circumstances in India. Our Indian students have seldom paid attention to the countries of Central Europe where the character of the holdings and the relations of Government to agriculture are much more akin to what they are, or should be, in India. The recent advances in Japan have, however, attracted the attention of many Indians as they have that of Raja Pyari Mohan Mukharjee, and as Japan has borrowed most of its improvements from Continental Europe, it is to be hoped that we have at last begun in an indirect manner to feel the influence and example of nations like Germany and Austria in matters of agricultural economy. The system of consolidating holdings was introduced in Japan as lately as the year 1899, but it has been known in Continental Europe in some form or other from the 16th century onward, and great use has been made of it since the individualization of agricultural economy caused by the great reforms of the first half of the 19th century. In France the process under consideration has been less used than elsewhere owing mainly to the greater tenacity of *laissez-faire*

principles in that country, but something of the same kind was recognised as necessary in Scotland and England in connection with the well-known series of Enclosure Acts. In Germany the consolidation of holdings was originally undertaken in connection only with the partition of common land, and it is still usual in that country to combine the operations for consolidation of holdings with those for the division of common land and the buying out of servitudes. We find the question of consolidation naturally enough mixed up, as it is in Raja Pyari Mohan Mukharjee's speech, with the question of the small size of holdings (morcellment), and the question has also its relations with other interesting subjects, such as the open field system, the system of mutual cultivation and that of enclosures, but for the purpose of the present paper it will be well to deal only with the proposals which have been made for the improvement of scattered holdings by consolidation.

There appears to be consensus of opinion in Europe that consolidation is economically a sounder condition of things than dispersion, and the action taken in the various countries of Europe towards this end has been conveniently summarised by Roscher in Chapter 78 of his *National ökonomik des Ackerbauers* (1903). Detailed accounts of the measures introduced for this object in Sweden, Germany and Austria will also be found in Bulletins of the Bureau of Economic and Social Intelligence recently issued by the Institute of Agriculture at Rome. We have not in England any definite term for the process in question which is sometimes described as 'adjustment,' sometimes as 'consolidation,' and sometimes by the terrible word 'restriping,' none of which terms has yet been definitely recognised in English technical literature. The German language on the contrary has a number of regular technical terms for the process, and the economists describe it by numerous synonyms such as Verkoppelung, Zusammenlegung, Arrondierung, Kommassation, Konsolidation, Feldbereinigung, and the like.

In most countries we find attempts made from time to time to effect the object in view by voluntary arrangements. Whether

the State is prepared to go further or not, it can at least encourage voluntary exchanges, as in Austria, by a total or partial exemption of such exchanges from Stamp and Registration Duties. In France it is said that the first Napoleon contemplated the exemption from Registration fees in such cases, but even this step has not as yet been taken and the affection of the French legislature for the process of consolidation has never ripened into any actual assistance. In Austria a law of 1869 goes so far as to allow the opposition of a mortgagee in a case of voluntary exchange to be overridden on reasonable grounds by competent official authority.

Such voluntary exchanges, however, as we know in India, go a very little way towards solving the difficulty, and, just as in most parts of India the State steps in to give official help in the partition of joint holdings, so in Central Europe the State considers it its duty to step in to give official help for the consolidation of scattered holdings.

The first step employed in Central Europe is for the officials to be approached by petition from the persons interested, and it is generally laid down that action will be taken only on the application of a certain proportion of the proprietors in the village. The actual proportion differs in different States, and has differed in the same State at different times. Sometimes a fixed proportion of the owners, by number, is considered sufficient. Sometimes this is qualified by requiring the applicants to represent a certain proportion of the area or of the rateable value of land in the village. As a rule, the proportion fixed is one-half or two-thirds, and the most suitable arrangement would appear to be something on the lines of that adopted by the Hanoverian law of 1842 which requires an application from the half of the number of persons interested on the understanding that these persons represent two-thirds of the area and two-thirds of the land revenue of the village, an arrangement which avoids giving excessive influence either to numbers or wealth. When the requirements of the law in this respect are too exacting, as for instance, in the Bavarian law of 1861 which requires the

applicants not only to be four-fifths of the number of owners in the village but to represent also four-fifths of the area and the revenue, the result is that little or no use is made of the law. It would be possible no doubt to allow a redistribution to be made of the property of those persons only who make the application, but apparently an arrangement of this kind has nowhere been introduced, the universal rule being that the whole area of the village should be made subject to redistribution. In some cases too the application may be vetoed for reasons given by the officials and in some States the officials may order redistribution independently of an application for special reasons, such as the necessities of irrigation or drainage projects.

The application having been sanctioned, the next step is to prepare a scheme of redistribution, and in this portion of the process there are great technical difficulties to be overcome, but to anyone acquainted with the procedure followed in partition cases in India, these difficulties should in this country not be found insurmountable. Where it is impossible to provide new land of exactly equal value with the old, the difference is sometimes made up by cash payments and in some cases such payments are limited to a variation of 10 per cent. from the value of the previous holdings. Special classes of cultivation such as gardens, vineyards, etc., are often left untouched, and an attempt is always made to give to each holder a class of land to which he is already accustomed. Pasture land, for instance, is not given to holders who have hitherto been entirely agriculturists and *vice versa*. Existing mortgages and permanent tenures are left as far as possible unaffected. Tenancy questions, such as we are acquainted with in India, are not prominent in Central Europe, but if the process of consolidation were introduced in India, the consent of the landlords would doubtless be required for a consolidation of tenants' holdings, just as it is in some parts of India already required for their partition. The main object of the process as carried out in Europe is to get each proprietor's land into one block or into as few separate blocks as possible. In Sweden, the law for a long time went so far as to insist on each

holder being given one block only, but the provisions of the law were subsequently so altered as to admit of two or more blocks in certain circumstances. All controversies arising in the course of the process of consolidation, including controversies regarding civil rights, are left, in Austria, to the decision of the officials carrying out the consolidation, appeals being at the same time allowed to be made by parties interested. The expenses of the process were originally shared, in Prussia, according to the advantage gained by each holder or, where this advantage cannot be ascertained, according to the value of his property, but there would appear to have been some difficulties with regard to the division of expenses on this basis, and a law of 1875 has fixed the cost of consolidation at a certain definite sum per acre dealt with. In Japan, the State itself contributes largely to the expenses of the process, and in 1909 the sum spent by the State under this head was reported to have exceeded £25,000, a sum which is said to have constituted one-fourth of the total expenses connected with agricultural administration, for the year, in that country.

There is one aspect of the case which has been pushed further in Europe than is likely to be the case in India, and that is the inducement caused by the consolidation of holdings for owners and tenants to leave the central village site, and live on the newly constituted holdings. In India as in Europe different tracts have different habits in this respect. In some the agriculturists are wedded to the village habitation. In others they already live each in his own holding. The enthusiasts in the cause of consolidation point out that when all the agriculturists are huddled together in one village site, they are exposed to much bickering and strife, to numerous petty thefts, and to the ravages of fire and infectious diseases, that they lose the value of true family life, that their cattle are not properly housed and so forth. They admit no doubt that when the people are together in a village site, police arrangements are easier, and they also confess that there are greater facilities for carrying out small repairs and petty operations by village artisans. At the same

time they are convinced that it is better on the whole for each family to live upon its land, and under the influence of this principle the law in Sweden has been so worked that during the last century more than one-third of the cultivators have been induced to leave their village sites and migrate to their own holdings. It is probably true enough that economically the scattered form of residence is more advantageous, but it is of course an open question how far the Government in any country would be prepared to exert any pressure to induce people to abandon habits to which they are wedded as regards their residence.

Apart, however, from any question of actual residence on holdings, much has been said in favour of the scheme of consolidation in itself. The advantages of a consolidated holding are already acknowledged by the Government in this country in those provinces where its orders in the matter of partition of joint holdings encourage the adoption of arrangements by which in the case of partition each owner should obtain his land as far as possible in one place. It is true that there are difficulties when the owner or tenant is attached to his land for sentimental reasons, and it is also true that a scheme of consolidation might conceivably be used (as schemes of partition sometimes are) for the purpose of petty annoyance. There are also cases where a village contains many different kinds of land (some tracts, for instance, being liable to floods and others not), and it would not be fair to require an owner or tenant in some such cases to hold all his land in one tract. In areas, moreover, which are subject to hailstorms, the visitations of hail are of so local a character that there are advantages in having one's holding in several different parts of the village.

Granting all this, however, it is urged that there still remain substantial benefits in a scheme of consolidation. The original object of the system adopted in Europe was to avoid litigation, and an amalgamation of holdings certainly has a tendency in this direction. The procedure was, however, maintained in Europe on account not merely of its effect on litigation, but also of the

agricultural benefits conferred by it. When, for instance, workmen are employed on an estate, it is easier to supervise them if they are all employed in one ring fence than if they are on scattered plots. There is, moreover, even in the case of villages where the agriculturists do not reside upon their holdings, a considerable saving, when the materials and agricultural implements have to be carried to one site only and not to various scattered spots, and a similar advantage is found in the conveying of crops after the harvest. There is also a considerable saving in the matter of ploughing where a holding has been consolidated. It has been calculated in Austria that the expenditure on the cultivation of land increased for every 500 metres of distance by 5·3 per cent. for manual labour and ploughing, from 20 to 35 per cent. for transport of manure and from 15 to 32 per cent. for transport of crops. Another advantage of a consolidated holding is that the occupier is then in a better position to fence his land from the trespassing of cattle, finds it easier to protect it from birds, and is able to undertake certain kinds of improvement such as sinking of wells. Cases occur every day in India in which an agriculturist would be ready to sink a well in his land if the whole area were in one spot. Another and very tangible advantage in the consolidation of holdings lies in the saving, which it entails, of the waste caused by uncultivated boundary baulks. It has been calculated that if a holding of $62\frac{1}{2}$ acres is composed of a single square piece of land, the length of the perimeter is 2 kilometres. If it is divided into four parcels also square, the perimeter is about 4·47 kilometres; for 10 parcels, the length of the boundary reaches 6·32 kilometres; for 20 parcels, it is 8·94, for 50 parcels, 14·28 kilometres. From this it can be estimated how much culturable area is wasted by baulks of say one or two yards in width, when the number of parcels in a holding is increased. The general result of a process of consolidation is acknowledged on all hands to be a very considerable saving in the net cost of production.

The authorities give us many instances of the savings which have been achieved by the process of consolidation. One of the

earliest of those noticed is that of a village in Prussia which was unable to pay its taxes and in which Frederic the Great enforced a system of consolidation with the result that in a few years the village was sold for a considerable sum. Instances are given in Roscher's book above quoted of various portions of the German Empire where the increase in value from consolidation has reached 50 or even 100 per cent., where the value of the meadow hay has been doubled, where the cost of labour has been reduced by $\frac{2}{3}$ and so forth. A case is given of a consolidation conducted over 100,000 morgen in Westphalia with the result that the peasants were able to dispense with 287 horses and 16 oxen, while at the same time increasing their cows by 1,197. A case is quoted from Bavaria where the value of land was raised by 64 rupees an acre through consolidation. In Japan we are told that the reduction in the cost of labour caused by consolidation may be put at 20 per cent. and the increase in the output of crops at 20 per cent. Then there is the case quoted by Mr. Keatinge of a village in Saxony with an area of 1,500 acres, 25 proprietors and 774 plots, where the number of plots were reduced by consolidation to 60 and an area of 10 acres saved in the roads and fences alone, with the result that the saving in culturable area at once met the cost of the proceedings (amounting to Rs. 2,000), and steps had to be taken for increasing the storehouses for agricultural produce. Many other similar instances could also be given to show the benefits which have accrued from the consolidation of scattered holdings.

As an instance of the amount of work actually carried out in other countries in connection with this procedure, mention may be made of Prussia where, between 1878 and 1880, 85,000 plots were reduced to 13,000. In the same country in 1898, 147,425 plots were reduced to 34,828, and between 1874 and 1898, 2,953,692 plots were reduced to 760,976. In Weimar, the number of plots was reduced from 479,997 to 55,028, and in Hesse Darmstadt the average number of plots in a holding has been reduced from 14 to 2. In Sweden also proceedings have been undertaken for many years on a gigantic scale, these and

allied operations having extended over 184,000 square kilometres or an area equivalent to two-thirds of the total area of Italy. In Japan the Government has also taken up the scheme in a comprehensive manner and has decided that, in order to improve the agricultural produce of the kingdom, operations must be carried out over an area of 600,000 acres out of which 1/10th has already been subjected to the procedure.

In view of the recommendations put forward in Raja Pyari Mohan Mukharjee's speech, it is well for us in India to acquaint ourselves with what has been done in this direction in other civilised countries. Similar schemes have received the attention of several of our agricultural experts, but they have not yet been seriously taken up by the revenue staff or by the agricultural public, and the above notes on the treatment of the subject in Europe have been put together with the object of placing those who are interested in the question in the way of obtaining for themselves fuller data and more extended information regarding the action which has been taken outside India to meet the class of difficulties which Raja Pyari Mohan Mukharjee has so prominently brought to notice.

THE IMPROVEMENT OF CROPS.

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FROM the general standpoint of the improvement of crops the more modern investigations on hybridization are not without interest. In this paper an attempt will be made to indicate the bearing of these investigations on the wider aspects of plant breeding work conducted with the object of obtaining better staples than those now cultivated. At the present time, in many countries, there is a considerable amount of state-aided effort devoted to the advancement of agriculture, and one of the chief activities of the various Agricultural Departments is concerned with plant breeding and selection.

1. THE PRESERVATION OF PURE LINES.

The most modern investigations on hybridization confirm the necessity of starting all plant breeding work from pure lines, the characters of which have been studied adequately. In the present state of knowledge, this is undoubtedly the best material available for the purpose and, consequently, the preservation of

the pure lines for the benefit of future workers becomes an important matter. This is particularly so in countries like India where reliable seed merchants do not exist, and where it is practically impossible to procure varieties of crops even botanically pure. Before hybridization work can be begun in India, it is necessary to make surveys of the particular crops studied and to separate them not only into botanical varieties and finally into pure lines but also to determine with precision all the characters of the pure lines themselves. All this preliminary work necessarily involves the expenditure of considerable time and money. As hybridization work proceeds, more and more pure lines of known gametic constitution will become, as it were, accumulated at the various stations, and the proper preservation of this material is an important matter, and becomes a valuable asset to the Agricultural Department concerned. It is important that it should not be lost and that it should be readily available for future workers in a manner somewhat similar to the way in which, at research centres, libraries of books are handed down to posterity.

The preservation and exchange of pure lines, the constitution of which has been proved, might easily become of very general importance. There is little doubt that hybridization work will, in the future, become in each country more and more restricted to a few centres, and it is very probable that the material of one country may be of use to the workers at centres in other countries. Thus there may very easily be useful exchanges of pure lines in Northern Europe and again in North America. The whole subject of the best means of preserving pure lines of economic plants of known gametic constitution is one which might well be taken up by the next International Conference on Genetics or by the International Association of Botanists.

2. PLANT BREEDING STATIONS.

The complexity of apparently simple morphological characters in wheat leaves little doubt that the number of factors

involved in characters of economic importance such as strength of flour, rust resistance and standing power are equally great. This in turn renders the isolation of new kinds, which breed true in all respects, from the progeny of a cross, a matter of greater labour and longer time than was at one period suspected. In addition, many of these characters are subject to the influence of environment, so that both the study of inheritance and the work of breeding improved varieties becomes increasingly difficult. If progress is to be made in the elucidation of the laws of inheritance on the one hand and in the production of improved crops on the other, it seems difficult to resist the conclusion that there can be little or no progress in either direction unless the work is organised in such a manner that it is restricted to a few centres adequately equipped. The publication of the early researches on inheritance, which followed closely on the rediscovery of Mendel's law, undoubtedly stimulated a large amount of hybridization work at agricultural experiment stations, and was the means of raising expectations that the improvement of crops was a simple matter and might be accomplished in a very short period. As a consequence, plant breeding was started at stations as an addition to an already overloaded programme, and the result has been to flood the literature with a mass of superficial results of no permanent value. Whenever plant breeding has been done with thoroughness and on a sufficiently large scale, it has invariably been found that the inheritance of characters is by no means such a simple matter as was first supposed, and the investigations conducted at such centres as Svalöf explain why it is that the numerous attempts at plant improvement made at agricultural experiment stations have not led to any very striking results. There is no doubt that plant breeding work is useless unless it is carried out on a large scale and with great thoroughness. This in turn can only be done effectively at experiment stations, at which this work is made the chief item of the programme. It would be better, therefore, for each country to maintain a few good plant improvement stations than to carry on superficial investigations at many centres.

3. THE BASIS OF SELECTION.

THE results obtained in a recent paper* have a considerable bearing on selection. It has been shown in wheat that characters, which appear at first sight to be simple, are in reality made up of several factors, each inherited independently of one another. The total number of factors in this crop will, no doubt, be found to be considerable. Natural cross-fertilization has been shown to be much commoner than was at one time suspected, and this supplies the means by which these factors can combine together to form a very large number of wheats, differing from each other by small amounts. The known complexity of botanical varieties in wheat is at once explained by the interplay between the numerous factors rendered possible by natural crossing. Consequently, the wheats of any region and especially those of a country like India, in which agriculture has been practised from time immemorial, supply material, which may well turn out to be a veritable gold mine, for the exercise of systematic schemes of selection. The careful comparison of the offspring of single plants may yield results of great value to the country. A similar state of affairs appears, from our observation in India, to obtain in several other crops in which self-fertilization is the rule. The comparison of the pure lines of these self-fertilized crops offers a line of work which may prove to be of the very greatest importance in agriculture and is moreover much simpler than hybridization investigations. The only difficulties involved are those relating to the interpretation of the results of the field trials in deciding whether or not an improvement has really been obtained.

These results also concern the question of the improvement of plants in which crossing is common. Here there is little doubt also that numerous factors are involved. These, however, have crossed so much among themselves that there has been no opportunity for the production of pure lines, so that the crops are a network of freely intercrossing forms. A large amount of

* Howard and Howard. *Memoirs of the Department of Agriculture in India (Botanical Series)*, Vol. V, No. 1, 1912.

systematic selection, extending over a considerable period, is, therefore, necessary before material, in any sense approximating to pure lines, can be obtained. While, therefore, the question of selection in self-fertilized crops is seen to be established more firmly as a result of recent work on hybridization, the difficulties in applying this process with success to cross-fertilized crops appear to be very much greater. Further, the question of the maintenance of the vigour of these latter crops, when grown in pure culture and when crossing is prevented, is a subject which, up to the present, has not received a very large amount of attention.

The maintenance of the vigour of crops in which a certain proportion of natural crossing takes place, is an important matter. As is well known, the result of cross-fertilization is to increase the vegetative vigour of the first and succeeding generations and the question arises what will happen if this crossing is prevented in the case of a pure line which has been selected for uniformity and which has been grown subsequently in pure culture. Will the vegetative vigour of such a culture be maintained, if there is no natural crossing or will it be better to permit a certain amount of crossing to take place in such a way that uniformity of product is not affected? In other words, is the aim to be the prevention of crossing altogether or the regulation of crossing? It may be possible in selecting crops to isolate two pure lines which yield similar produce and to allow these to cross among themselves so as to secure for the crop the increased vigour which follows this process. Such a matter can obviously only be decided by experiment. In considering this question we must not permit ourselves to be unduly influenced by the demands of the market for certain classes of produce. The requirements of the market are naturally of great importance, but this is not the only factor to be considered by a Government Agricultural Department like that of India whose business it is, in introducing innovations, to look at the matter from all points of view including that of the welfare of the Indian cultivator. It might be no advantage to the cultivator, after the indigenous mixed crops of a tract have been

replaced by a pure line with uniform produce, if this improvement were followed by a diminution in vegetative vigour. The plant itself, which is concerned solely with its own maintenance and reproduction, often under conditions relatively unfavourable, must also be considered. In the struggle for existence it is at least questionable whether such matters as uniformity of product are as important to the plant as the power to grow vigorously and to maintain itself well over an average of years. Looking at the subject as a whole it seems desirable that the scientific basis underlying the selection and growth, in pure culture, of cross-fertilized crops should be very thoroughly investigated. On the results obtained will depend not only the direction in which the crop can best be improved but also the methods of seed distribution which should be adopted.

RABI FIELD EMBANKMENTS.

BY

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Few people are aware that in the upper part of the Nerbudda Valley, a system of *rabi* cultivation exists which is, in its way, unique and which so far as is known is not found in any other part of India.* The soil in those parts of the Jubbulpore and Narsinghpur districts, where this system obtains, is a heavy black clay unfitted for the cultivation either of *dhan* (paddy) or of the superior *khari* crops, such as cotton or *juari*; but it is eminently suited to wheat which is the staple crop of the Nerbudda Valley. The valley here is a level plain, averaging about 20 miles in width and bounded by the foot hills of the Satpuras to the south and by the Hiran and Nerbudda rivers, which flow directly under the great Vindhyan escarpment, to the north. The whole of this tract from north of Jubbulpore to twelve or thirteen miles beyond Narsinghpur, a length of between 60 or 70 miles, is heavily embanked. In the west of the Bilaspur district and in other scattered areas in Chhattisgarh a somewhat similar system is found. In these districts the practice has arisen of turning low embankments in black soil rice fields into larger *Bandhias* (as they are called) for wheat, and similar to the *haveli*† type described above. The *Takari* loans of 1897 famine greatly extended this practice which enables a fine crop of wheat to be grown in the field itself, and

* A very similar system prevails in the Gaya District of South Bihar.—(Ed.)

† Black soil tract of the Nerbudda Valley.

the rice crops in the field below it to be irrigated when the bank is cut. The sum of these advantages seems to outweigh the potentialities of double cropped rice, which was previously grown in these areas. The system which is described in some detail in this article, however, refers to the Upper Nerbudda Valley and consists briefly in holding up the monsoon rainfall in the embanked fields, which are enclosed on all four sides, and in retaining in the fields the water so impounded until sowing time approaches, when it is let out and the fields sown as soon as the land is dry enough. The system is of very ancient origin and was developed in the very fertile plain to the north-west of Jubbulpore city, where land has probably been embanked for some hundreds of years commencing from the time when the Hindu cultivators from the north first entered the valley and ousted the indigenous Gond. From this centre, the system seems to have crossed the Nerbudda into the Narsinghpur district within more recent times. It also received an extraordinary impetus in the Bijeraghogharh pargana before the Mutiny when the Hindu ruler of that time Raja Prayag Das encouraged his cultivators to embank by the promise of a protected tenure.

The area of the Jubbulpore embanked tract is roughly 200,000 acres, and that of the neighbouring Narsinghpur district is rather less than 100,000 acres, which does not include small separate areas, in which conditions being suitable, this system has also been introduced. The embankments are of two kinds, viz., the *Bandhan* and the *Narbandh*.

Narbandh.—The former which will be discussed more fully later on are typical of the tract and consist of level fields surrounded on each side by an embankment. They become filled by the rainfall alone. The *Narbandh*, on the other hand, is built on sloping land or across a *Nala* and is a much bigger construction. A *Narbandh* is filled by the collection of rain-water from a considerable area. The silt thus brought down in suspension slowly levels up the bed of the *Narbandh*, but this is a very slow process. It is said that a builder of a *Narbandh* does not himself,

as a rule, realise the full benefit of his industry in the shape of better crops, but expects his son to do so. As *Narbandhs* are comparatively unimportant in the tract we are discussing, owing to its level nature not necessitating their construction, a further consideration of them may be omitted and a more detailed description of the typical *Bandhan* proceeded with.

The Construction of Bandhans.—In the case of typical *Bandhans* of the Jubbulpore-Narsinghpur *Haveli*, only flat stretches of good soil are usually embanked. These soils are of two kinds and are named *Kabar* and *Mund* each being generally divided into two classes, *viz.*, inferior and superior.

Kabar I is a very heavy black clay containing practically no sand or stony nodules. When dry, it becomes very hard and tough and cracks widely. A fractured lump of dried *Kabar* possesses a glazed appearance. *Kabar II* is a slightly inferior edition of the above. It occasionally contains a small amount of sand, and in that case hardly cracks at all when dry. Other kinds contain small *Kankars* or nodules of limestone, such soil being difficult to distinguish from *Mund*. *Kabar* is in all cases, however, a heavier soil than the latter, is extremely retentive of moisture, but is apt to become hard rapidly, which makes it unculturable unless the seed is drilled just at the right time.

Mund is also divided into a superior and inferior class. It is a lighter soil than *Kabar*, is more free working and always contains lime-stone nodules. In the poorer classes of *Mund* these are numerous and of large size, and the soil is greyer than it is in the case of true *Mund* and at the same time is not so fertile and is less retentive of moisture.

Work on the construction and repairs of embankments is always done in the hot weather after wheat harvest is over. The soil is taken from the inside of the field next to the *Bund* and is dug out in great cubes by means of a crowbar, the blocks of earth being built up one on the other like stones in a wall. A typical old established embankment is a substantial construction, $3\frac{1}{2}$ to 4 feet high and as much as 10 ft. through at the base.

A new embankment requires to be raised about 2 feet at the end of the 2nd and 4th years, after which *Kabar* bunds require little attention for some time but *Mund* bunds, which flatten down much more rapidly, require attention every six years or so.

If the monsoon arrives with a big burst of rain, the embankment is liable to be breached in several places, more especially in the case of *Kabar*, which cracks greatly in the hot weather. If, however, a few showers precede the arrival of the real monsoon, the clay expands, the cracks close up, and there is little fear of a breach. Newly made embankments are especially liable to burst, and in order to strengthen them the cultivator frequently plants the sides with deep-rooted grasses such as *Dhavi* (*Saccharum moonja*) or *Kans* (*Saccharum spontaneum*), while the tops of the bunds are sown with *Til* (*Sesamum*) or *Mung* (*Phaseolus mungo*). *Bandhans* are of all shapes and sizes, some fields may be 50, while others are only 2 or 3 acres in extent. The area and shape depend on the contour of the land to a large extent, slight irregularities in the general flatness of the plain being made use of, and the cultivator, although he possesses no instruments, is rarely wrong in his levels. The size and boundary lines of the different holdings also partly account for the irregularly shaped fields which are sometimes noticed.

Method of Cultivation.—The wheat stubble is uprooted, more or less, by the *Bakhar* (a kind of harrow) at the end of the hot weather, but in some cases even this preliminary cultivation is not undertaken. The bunds are raised, strengthened and repaired in plenty of time before the expected date of the monsoon. If the rains are good, the bunds will fill rapidly in August, as by that time the whole of the sub-soil over a large area has become thoroughly saturated, practically all the rainfall being held up. Heavy rainfall is required in August and September to fill the bunds; if only light, even though continuous, rain falls, the bunds will not fill. All weeds except *Kans* are drowned out, but the latter, unless the water is more than 2 feet deep, flourishes. In August and September it is a common

sight to see the cultivator and his family standing up to their knees in the water, pulling up the *Kans* by its roots. The *Kans* after being uprooted is tied into bundles and together with weeds cut from the sides of the bunds is thrown into the water to rot. Water remains in the *Bandhans* until the beginning of October, and is then run off. The letting out of the water is a gradual process. As has been explained above, the practice of embanking is a very old one in the tract under reference, and the cultivators know by long experience which fields ought to be drained first. A narrow cut is made in the wall of the embankment, and the cut is deepened by degrees to allow the water to escape gradually and to avoid flooding out or scouring the field below. In most fields the portions round the sides, owing to the removal of soil for raising the embankment, are lower than the rest of the field, and are not sown until some time after, as they remain damp much longer.

Kabar soil requires very careful treatment for, if not sown at exactly the right time, it sets hard and becomes impossible to sow. A careful cultivator therefore drains one *Kabar* field at a time and works night and day with all the seed ploughs (*Naris*) he possesses, in order to get his seed in, at the right time. Parts of the Jubbulpore *Haveli*, where *Kabar* is prevalent, present a curious sight at night during the busy season. The *Kabar* fields are ringed round with flaming torches fixed to the ends of long bamboos and placed upright in the soil at regular intervals, while the long string of *Naris* travel in a curved line from one end of the field to the other, the tired bullocks being urged on by loud shouts from their drivers.

Mund does not get out of condition nearly so rapidly, and the sowing of this class of land proceeds much more leisurely. In the Narsinghpur district, it is usual to give *Mund* soil one *Bakharing* after the water has been drained off and before sowing, but in parts of Jubbulpore this is often dispensed with and the *Nari* is put straight on to the land as it becomes sufficiently dry after draining off the water, as it is usually absolutely free from weeds.

The crops grown are the usual *Rabi* ones. The favourite mixture is *Birra* (wheat-gram), the percentage of gram ranging from $12\frac{1}{2}$ to 25% according to the class of soil. Pure wheat is hardly ever grown, as the cultivators say that the presence of gram keeps up the fertility of the soil, thus showing a belief in the renovating powers of leguminous crops. Other common crops are gram (*Cicer arietinum*), *Masur* (*Ervum lens*) and *Teora* (*Lathyrus sativus*), while linseed is also cultivated to some extent when prices are favourable. *Kabar* is not supposed to be so suitable for wheat as *Mund*, and the percentage of gram in the *Birra* is much higher in consequence. Some of the best *Kabar* land is double-cropped. Early coarse *Dhan* is sown broadcast as a catch crop, and is followed by either *Birra* or gram.

The standard outturns for this tract as given by Mr. H. R. Crosthwaite, Settlement Officer, in his Preliminary Report on the Jubbulpore Tahsil are as follows :—

Wheat	...	...	...	...	700 lbs.
Gram	...	...	...	...	700 lbs.
<i>Masur</i>	...	...	...	...	700 lbs.
Linseed	...	...	...	...	300 lbs.
Rice (uncleaned)	...	...	...	...	800 lbs.

The best cultivators in good years raise much bigger crops than these, however, and I have seen many wheat fields which have threshed out at over 1,000 lbs. per acre.

Conditions Essential for the Practice of this system.—Having thus briefly described this system of cultivation, it will be interesting to note the conditions necessary for its practice. The first essential is a level area of heavy clay soil of considerable extent. Unless the area is level, the cost of embanking becomes relatively too great and the area of the land enclosed, which is submerged by water, too small. For this reason this system is not likely to receive widespread acceptance in the *Damoh Haveli* which is somewhat undulating, but where other conditions seem favourable. Heavy soils are necessary to hold up the water.

An analysis of *Mund* soils from an embanked field near Sehora in the Jubbulpore District made by Mr. F. J. Plymen, Agricultural Chemist, Central Provinces, is given below :—

Coarse Sand	...	...	...	...	0.18
Fine Sand	...	...	...	...	8.26
Silt	...	...	...	...	17.12
Fine Silt	...	...	...	...	24.07
Clay	...	...	...	...	33.00
Loss on ignition	6.39
Moisture	7.66
Calcium Carbonate	0.13
Soluble in dilute acid	3.19
					<hr/>
					100.00
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It will be noticed that clay and silt together comprise nearly 75% of the total contents.

The area to be embanked should be extensive and compact. In introducing this system into a new tract, it is seldom much use embanking less than about 100 acres in one place. In smaller areas, owing to drainage from outside the embanked area, the sub-soil will not become properly soaked, and in consequence the *Bandhans* will not remain full. This circumstance has been a source of much difficulty and disappointment where individual landowners or cultivators have attempted to introduce this system. The rainfall must also be good and must be characterised by heavy individual downpours. In both Narsinghpur and Jubbulpore, the rainfall averages between 50 and 60 inches as a rule, and falls of three or more inches within the 24 hours are not uncommon.

Lastly, a knowledge of the management and construction of *Bandhans* is necessary, and mutual agreement among the cultivators as regards the time and order of letting out the water from different fields is essential. In the Hoshangabad district in the year 1902 several blocks of land were embanked by Government on this system to act as a demonstration. The sites were on the whole well chosen, and local conditions of soil and rainfall were good, as the *Bandhans* fill every year. The

people, however, to whom this system is new, do not know how to manage these bunds and have no settled agreement regarding the order of letting out water, so that the demonstration up to the present has been only a qualified success.

Advantages of the System.--One of the chief advantages that obtains with this system is the protection afforded against failure of the late monsoon rains, which are so important in this part for *rabi* sowings. If the rainfall in the early monsoon has been heavy, the bunds fill and a moist seed bed is assured. In the Jubbulpore district, where the system of embanking is a very ancient one, practically all available land is embanked but the practice has spread into the neighbouring district of Narsinghpur only within comparatively recent years, and increased activity in embanking fields has always been shown during a cycle of years in which the late rains have been scanty. The great success of this system in the famine year 1896-1897, when a dry September followed a very wet August was especially remarkable. Mr. C. A. Clarke when Deputy Commissioner of Narsinghpur made an enquiry into the matter and found that from 1866 to 1896 the average rainfall was well over 50", and that in only one year (1868) was the fall less than 30." From 1895-1896 onwards, however, the late rainfall was very scanty. For seven years in succession no rain fell in October, whereas before this period any thing from 3 to 8 inches usually fell during this month. The acreage recorded as embanked at Settlement (1885-1894) was 50,000 acres, and since then this has been increased by 25,423 acres or more than 50%. There is little doubt, therefore, that the cultivators regard embanking as a species of insurance against failure of the late rains, and consequently rapid development of this form of improvement took place during the cycle of twelve dry years following 1896.

Another advantage that is claimed for the system is that fields so embanked become more fertile than similar unembanked land. The fact that weeds, grass, etc., are thrown into the water to rot during the rains is stated to be one of the causes. It is possible, as some authorities think, that the water

in the *Bandhans* possesses more solvent power, owing to the presence in solution of carbonic, humic, crenic and other organic acids resulting from the decaying vegetable matter, and that the rate at which phosphorus, potash and other mineral plant foods are liberated from the soil may be accelerated. There is no proof one way or other as no investigation into the matter has yet been made. On the other hand it would seem possible that the water-logging of the soil might tend to inhibit aerobic bacterial activity to a great extent. Also the percentage of organic matter in the soil does not seem to be very greatly increased. Thus a sample of *Mund* soil from an old embanked field near Sehora in Jubbulpore district was compared with one from a field of unembanked *Maryar* (a very similar soil) in Hoshangabad. Both had been cropped with wheat or *Birra* for a large number of years continuously, and neither had been manured so far as could be ascertained for a very long time if at all. The results were as follows, the analysis being conducted by Mr. Plymen :—

Soil.	District.	Loss on ignition.
<i>Maryar</i> ...	Hoshangabad	6.20
<i>Mund I</i> ...	Jubbulpore	6.39

The moist seed bed, continuous cropping with a leguminous mixture, and absence of erosion may be sufficient to account for the good results obtained, while the soil, being derived in all probability from the mixed geological formations which are found in the hills surrounding this tract, is probably in itself peculiarly fertile.

Undoubtedly the greatest advantage accruing from this system, however, is in the saving of labour. In the Western half of Narsinghpur and Hoshangabad, where the wheat soils are similar but not embanked; the wheat grower, in a season with favourable breaks, will give the following cultivation. The stubble is *Bakhared* up during the hot weather, one *Bakharing* is

given after the rains have commenced and is followed by a ploughing. During breaks in the rains three or four more *Bakharings* are given and the field is again *Bakhared* before sowing. In all one ploughing and four or five *Bakharings* are required. On an embanked field in Jubbulpore, on the other hand, the stubble may be *Bakhared* during the hot weather, but no more cultivation is given, as the water in the fields keeps the land free of weeds.

In Narsinghpur the custom is generally to give one *Bakhar* after letting out the water and before sowing the seed. Cultivators in the *Haveli* tract keep far fewer cattle in proportion to the size of their holdings, than in the unembanked areas; indeed instances are not wanting where men in possession of quite substantial areas keep no cattle at all, and merely hire them for the sowing season. The saving of labour is therefore considerable and is, I think, one of the chief causes of the popularity of this system.

Drawbacks.—Having enumerated some of the advantages it is only right to turn to a consideration of the drawbacks of this system. In years of heavy late rainfall the *Bundhans* do not give such good results as the unembanked fields. Last year (1911-12), for instance, two inches of rain early in November delayed sowings very greatly and as a consequence the crops were very late. Late crops of wheat in this tract are nearly always inferior to early sown wheat, and in addition are more liable to the attacks of rust. In the years 1892-95 this disease caused great loss and the late sown wheat of the *Haveli Bundhans* suffered most severely. Rust appeared again in 1911-12 and the late sown wheat of the *Haveli* again suffered more heavily than wheat sown earlier in *Tagar* land.

An incidental disadvantage of this system, which has, however, been avoided in the more recently embanked area in Narsinghpur is the practically complete absence of village roads, and consequently of carts, in the Jubbulpore *Haveli*. All produce is purchased in the village by travelling dealers and conveyed by pack animals on foot-paths along the top of the

bunds to the railway. The absence of carts is especially felt at harvest time as the threshing floors are always near the village, and the whole crop has to be brought in from the fields on head loads sometimes from a distance of two miles. There is little doubt, however, that the advantages largely out-balance the drawbacks, and that the embanked field is a much more valuable asset to its owner in these parts than a field not so improved.

YIELD AND QUALITY IN WHEAT

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IN the literature relating to yield and quality in wheat there appears to be a considerable confusion of ideas. As this is likely to stand in the way of progress, an attempt has been made in this paper to define the position in so far as it applies to India. There is a general opinion that in some manner yield and quality are antagonistic and that high yielding wheats are always of poor quality. On the other hand, if quality is aimed at, then the yields are necessarily poor. At a recent discussion on the improvement of English wheat at the Farmers' Club in London these erroneous ideas were advocated by Percival,* who maintained that, under English conditions, yield and quality cannot be combined.

The results of our experiments indicate that there is a definite connection between yield and quality. These experiments

* *Journal of the Farmers' Club*, 1912, p. 80,

can best be understood and their significance realised if the two aspects of the whole question are separately considered. In the first place, the experimental evidence on the possibility of combining high yield and high quality in the same wheat must be considered. The second point relates to the conditions under which, in any particular wheat, the best quality can be obtained.

The first aspect relates to the combination of yield and quality in the same wheat. On this subject there is a considerable volume of Indian evidence. At Pusa several new hybrid wheats with high grain qualities, raised from Muzaffarnagar, have for several years given higher yields than either parent. These are Pusa 100, 101 and 106, which were tested by Mr. Humphries in 1910 and found to behave like Manitoban good grade wheats produced in a dry season.* Several other wheats from the same cross, which have not yet received numbers, gave equally good results in 1912. In the trials of the strong wheats in 1911, Pusa 12 at most stations gave a higher yield than Muzaffarnagar, a result which is almost always the case when the two wheats are grown side by side at Pusa. In the case of gram (*Cicer arietinum*, L.) at Pusa, where many pure lines have been grown, the line with the highest quality is by far the highest yielder. Experience shows that there is no inherent antagonism between yield and quality, and that both are possible in the same wheat.

Considerable attention has been paid at Pusa and afterwards at Cawnpore to the study of the conditions under which any particular wheat gives the best possible sample. As might have been expected, the best samples were produced when the wheats gave the highest yield. The best samples were obtained after hot weather cultivation and clean fallowing during the monsoon, when the objects aimed at were the absorption of water and its retention in the soil and subsoil combined with the destruction of all weeds. In this way yields of over 40 bushels to the acre

* Howard and Howard, *Bull.* 22, *Agricultural Research Institute, Pusa*, 1911, p. 14.

have been obtained at Pusa without manure, without rain after sowing and without irrigation. The higher the yield, the finer and more uniform the sample has been while the results of the milling and baking tests have always been most favourable in years of greatest yield. Thus in 1910 at Pusa, when the yields were the highest ever reached, the samples were particularly well spoken of by Mr. Humphries and gave very good results indeed when milled and baked. In 1911, the yields due to very unfavourable weather were lower, and in that year the samples were relatively poorer in appearance and the milling and baking results were also to a certain extent adversely affected. In the tests of Muzaffarnagar grown at the various stations a similar result has been obtained. The Cawnpore and Pusa samples have always done best in the milling and baking tests. At these centres this wheat has uniformly given higher yields than at the other stations. There is no doubt, therefore, that in wheat growing the best sample is produced under those conditions which give the highest yield. This in reality clears up the whole matter as will be obvious from the experiments described below. These relate to hot weather cultivation and drainage—two important factors in wheat production in the alluvium.

A. HOT-WEATHER CULTIVATION.

In previous papers* attention has been drawn to the marked effect of hot-weather cultivation in the production of wheat and other crops, both *kharij* and *rabi*, in the alluvium of the Indo-Gangetic plain. During the early period of the wheat experiments at Pusa, when attention was being paid to the best methods of growing the crop under Indian conditions, it was decided to try the effect of opening up the stubbles immediately after harvest

* See *Nature*, Feb. 17th, 1910; *Memoirs of the Dept. of Agri. in India (Botanical Series)*, Vol. III. No. 4, 1910, and *Pusa Bulletin* No. 22, 1911.

and so exposing the soil to the hot dry winds which prevail at this period of the year. The stubbles were ploughed several times and thoroughly opened up resulting in the production of a deep dry mulch of fine soil in which no growth of weeds was possible. This enabled all the early monsoon rains to be absorbed and the subsequent procedure consisted in sufficient cultivation to keep down weeds and to break up the surface so as to allow of the percolation of more water into the subsoil. In this manner sufficient moisture was absorbed for a wheat crop of over forty bushels to the acre and the fields rapidly became free of weeds. In the lighter lands, the water holding capacity of the soil was increased by ploughing in crops of *sun* (*Crotalaria juncea*, L.) raised on the early monsoon showers, but this has not yet been found necessary in the heavier lands.*

The effect of hot weather cultivation and moisture conservation was then tried at Cawnpore and, as at Pusa, the effect was instantaneous. The detailed results are published elsewhere and it is sufficient to say that crops of between 25 and 30 mds. to the acre of high quality wheat have been produced using half the quantity of irrigation water employed by the cultivators in the neighbourhood.

At this point it became desirable to determine the actual crop increase resulting from hot weather cultivation. It was unfortunate that both at Pusa and at Cawnpore all the land had been thoroughly cultivated in the hot season for at least two years before the experiment was started and none of the area had been left in its original condition. Under these circumstances it was expected that no great differences would be

* If green manuring with *sun* is attempted on heavy wheat lands in Bihar, in years when these soils are water-logged after the green crop is ploughed in, the resulting wheat crop is always less than if no manure had been added. The addition of the green crop seems to accentuate anaerobic fermentation in the soil and to reduce the available nitrogen for the wheat crop. Fortunately such heavy soils retain water well and are not in need of green manure for this purpose. The fact that green manuring these heavy lands for wheat reduces the yield seems to indicate that on rice lands in Bihar green manuring with *sun* would increase the yield considerably.

detected the first year, and that it would take some time for the fertility to fall to the ordinary level of that exhibited by the cultivators' fields.

The experiment at Pusa was commenced after the harvest of 1910 and a level plot of typical wheat loam of high moisture retaining capacity was selected for the purpose. One-half was cultivated during the hot weather, the remainder being left untouched till after the beginning of the monsoon. Across both plots a strip of land was manured just before sowing with Nitrate of soda, at the rate of 224 lbs. per acre, and the results are shown in the following plan :—

Ploughed after the beginning of the monsoon.	Ploughed from the hot season onwards.	
32.02	37.89	Unmanured.
35.73	37.52	Manured with Nitrate of soda at the rate of 224 lbs. per acre.
32.02	37.89	Unmanured.

The numbers in the table are bushels per acre.

The figures show that late ploughing caused a fall in the crop of six bushels of wheat to the acre, and that the dressing of Nitrate of soda partially made up for the deficiency on the late ploughed plot but added nothing to the yield of the early ploughed plot.

The consistency, absolute weight and nitrogen content of the samples in this experiment are given in the following table. Those manured with Nitrate of soda were darker in tint than the

others, while those from the late ploughed plot were comparatively pale in colour and not so well grown as the rest :—

Treatment of the land.	Consistency.			Weight of 1,000 grains in grammes.	Nitrogen percentage.	Yield per acre.	
	Hard.	Intermediate.	Soft.			Mds.	Bushels.
Ploughed early ...	88	12	0	32.29	2.49	27.62	37.89
Do. + 2 cwt. of nitrate of soda per acre.	88	12	0	31.48	2.57	27.35	37.52
Ploughed late ...	71	29	0	30.91	2.28	23.35	32.02
Do. + 2 cwt. of nitrate of soda per acre.	81	19	0	31.11	2.48	26.05	35.72

The standard manure consists of 40 seers and is equivalent to 82.27lbs.

In the following year, 1911-12, the experiment was repeated on the same plot, but in this case no nitrate of soda was applied. There was a distinct difference in vegetative vigour between the plots and this is reflected in the yield of grain as will be seen in the results obtained.

1. Early ploughing—35.41 bushels to the acre.
2. Late ploughing—22.90 bushels to the acre.

The difference in yield during the past year was twelve and a half bushels per acre, or about twice that obtained the first year of the experiment. The results indicate that the effect of hot weather cultivation is cumulative and that the effects are not lost for some time. The experiment is being continued until the yield of the late ploughed plot becomes steady, after which it is proposed to reverse the treatment of the two plots.

As regards quality, the appearance of the wheat from the late ploughed plot was distinctly inferior to the other. It was paler in colour and not so well grown as that from the early ploughed plot. In this case while the plot with the higher yield gave the better quality, the fall in yield was greater than the difference in quality. This agrees with our experience at Pusa in wheat growing that in the case of the same wheat any adverse condition always affects yield much more than quality. When quality is sensibly lost, it is almost certain that the yield is poor.*

B. DRAINAGE.

During the progress of the wheat investigations in India one important factor in the growth of this crop has frequently been observed. This is waterlogging both previous to and during the growth of the crop. If wheat lands in Bihar are inundated for any length of time during the monsoon, or if portions of the fields are continuously waterlogged for long periods, then a sour or semi-marshy condition of the soil results which is shown by a yellow crop of poor vegetative vigour and low yield. Often the consistency of the resulting sample on such areas is affected and a large proportion of mottled and soft grains are produced, which spoil the appearance of the sample and lower its market value. Similar results are to be seen in canal irrigated tracts in low-lying areas of the fields which get too much water and in which the soil becomes semi-waterlogged for long periods. These effects were distinctly visible in the wheat plots at Bankipore and Dumraon in 1911, where wheat followed

* In connection with these experiments the behaviour of the continuous wheat plot at Pusa may be of interest. This is a strip of typical wheat land which, for the past five years, has been cropped every year with wheat without manure. In 1911-12, the fifth year of the experiment, the yield per acre was 36.25 bushels, which is the highest yield of the variety (Pusa 22) so far obtained at Pusa. No diminution in vegetative vigour was observed. On the contrary, the growth was so great that a large portion of the crop was laid by wind soon after coming into ear which circumstance diminished the yield of grain. It will be interesting to see for how much longer these yields can be obtained and whether any organic matter besides the stubble need be added to the soil.

rice. The samples also contained a high percentage of soft and spotted grains. Drainage is therefore an important matter in wheat growing in India both as regards yield and quality even in areas where the crop is grown without any appreciable rainfall during the growth period. The long periods of rainless weather in India are apt to distract attention from the necessity of drainage. In reality however, in a country where most of the rainfall is compressed into three months, the necessity of perfect drainage is even greater than in localities where the total precipitation is more evenly distributed through the year.

At Pusa, during the wheat growing season 1909-10, which was preceded by a heavy monsoon, alternate strips of wheat and gram (*Cicer arietinum*, L.) were sown on a plot of heavy wheat land which was imperfectly drained during the monsoon. It was observed that while the gram was exceedingly good the wheat was poor and stunted with yellowish foliage and exceedingly small ears. The total crop was only a small fraction of that obtained on the rest of the field where the surface drainage was sufficient. The markedly different behaviour of a cereal and a legume, growing under the same conditions in the presence of sufficient soil moisture, suggested that the explanation of the difference would be found in the nitrogen supply in the soil. Accordingly the matter was made the subject of an experiment in the following year, 1910-11.

The monsoon of 1910, although well distributed, was small in amount and no waterlogging took place as the showers were absorbed and practically no water drained off the surface. In consequence the land had to be artificially water-logged, and this was done during the month of September by pumping water from the river on to the area under experiment. The land selected for the experiment was well ploughed in the hot-weather of 1910 and fallowed till the end of August when the central portion was embanked and artificially kept wet during the whole of September. After drying sufficiently the water-logged portion was harrowed and ploughed up and managed in the ordinary way till sowing time. Across the middle of the

plots a strip was manured with nitrate of soda just before sowing, the total amount added being four cwt. to the acre. At first the waterlogged area did best due to the abundant moisture, but after tillering it rapidly fell behind the areas on either side. The nitrated strip in the waterlogged area soon became well marked, but was hardly distinguished on the weathered plots on either side. The yields obtained are given in the following plan :—

The effect of waterlogging wheat land at Pusa in 1910.

Normal cultivation.

Waterlogged during September.

Normal cultivation.

34.45	15.55	29.14
SHADED AREA TREATED WITH 4 CWT NITRATE OF SODA PER ACRE		
35.92	25.17	26.53
34.45	15.55	29.14

The numbers in the plan are bushels per acre.

It will be seen that the effect of waterlogging for a month was to reduce the yield by about sixteen bushels to the acre while the nitrate of soda on this area increased the yield by nearly ten bushels. The effect of the manure on the non-waterlogged plots, as was expected, was very little. The results prove that the effect of waterlogging wheat lands in the previous monsoon is to interfere with the nitrogen supply of the crop and to lower the yield.

This result is of some general interest in Indian agriculture and particularly in those tracts of the plains like Bihar where

rice and wheat are both grown. The low lying areas in these tracts, which receive drainage water from the higher lands, are generally planted in rice, and these lands are often inundated and always waterlogged for long periods during the growth of the rice crop. The rice plant, however, thrives under these conditions and is able to take up its supply of nitrogen under waterlogged conditions most likely in forms such as ammonia which are not suitable for other crops. In wet years like 1909 in Bihar the waterlogged and marshy conditions associated with rice culture may be said to have spread beyond and above the paddy fields and to have affected the wheat lands. This naturally influenced the soil processes and consequently the supply of available nitrogen for the wheat crop. Gram, however, being able to supply itself with nitrogenous food-material, was not affected and could thrive where a cereal like wheat to all intents and purposes starved.

From the economic standpoint the results of this experiment point to the great importance of drainage in the alluvial soils of India and the need of the limitation as it were of rice conditions to the areas which produce this crop. Where canals are used for watering the wheat crop it is also essential that the fields should be level, so that all parts are equally watered. Where low areas exist, the surplus irrigation water drains into and waterlogs these areas and the result is a small crop of poor quality. On the black cotton soils of the Central Provinces it is often observed that the low lying areas of the wheat fields often yield a larger proportion of spotted and soft grains than those parts which lie higher or are better drained. This partial waterlogging, which is more frequent in the black cotton soils than in the alluvium, is probably one of the chief causes of the unevenness in the consistency of the wheat often grown in Central India. The greater unevenness of the fields in Peninsular India probably follows from the fact that the levelling beam (*sohaga*) does not seem to be in general use in these regions. It is most important from the point of view of the miller that samples should be uniform in consistency otherwise a lower price is obtained for the wheat. The cultivator in

growing wheat of mixed consistency loses twice over. In the first place the yield is reduced and in the second place the quality is affected.

These experiments clearly indicate two of the main factors in the plains on which optimum yield and quality in wheat depend.* If cultivation is inadequate, the yield falls and the quality is also affected. Want of drainage lowers the yield, affects the consistency and also lowers the quality. As regards wheat production it may be said that the best quality is obtained when the optimum yield is produced and that in any particular wheat the ryot who produces the greatest yield has also secured the best quality possible in that wheat. If under these circumstances he grows a wheat in which high yielding power and high quality are combined, he is then getting the greatest financial return for his labour.

* Another important factor in wheat-growing in the alluvium, in addition to hot-weather cultivation and drainage, may be mentioned. This is the treatment of the subsoil after it has been compacted by the monsoon rainfall. Experiments conducted at Pusa on the last three wheat crops, 1909-10 to 1911-12, have clearly indicated the advantage of a deep-ploughing towards the end of the monsoon. This aerates the subsoil, increases the root-range of the wheat plant and results in a considerable improvement in the standing power of the crop as well as a better filled and more attractive sample. In the crop of 1911-12 the results of late deep-ploughing were particularly well marked. This cultivation must however be carried out without an undue loss of moisture—a matter of some difficulty in certain years with soil-inverting iron ploughs. On large estates it is possible that the best results will be obtained by the use of some form of sub-soil plough.

SOME FOES OF THE FARMER IN THE CENTRAL PROVINCES AND HOW TO DEAL WITH THEM.

BY

D. CLOUSTON, M.A., B.Sc.,

Deputy Director of Agriculture, Southern Circle, Central Provinces.

OWING to the very large area which still remains under jungle in the Central Provinces there is probably more damage done to crops by wild animals in these provinces than in any other part of India. Wild pigs abound everywhere and make nightly raids on cane, *juar*, rice and other crops on which they feed all night returning to their haunts in the jungle in the early morning. One cane-grower lately informed me that his field of thick canes of which he had obtained the seed from the Department of Agriculture was damaged to the extent of Rs. 300 by pig in one night.

2. The counter measures that one naturally suggests in this case are (i) to destroy as many pig as possible, and (ii) to protect the fields by fences. But as the pig is a nocturnal feeder and lies hidden during the day in the jungle or grass-covered wastes which are often many miles distant from the crops on which it feeds, to reduce their number to any appreciable extent will, I believe, take many years. In some districts of the Central Provinces cultivators are granted gun licenses on condition that they shoot a certain number each year. In the North of the Provinces a system of pig hunting with dogs has been organized and some thousands have been killed this season in that way. In villages in jungly tracts pigs are often caught and killed in pits. Otter traps have been tried by the Department of

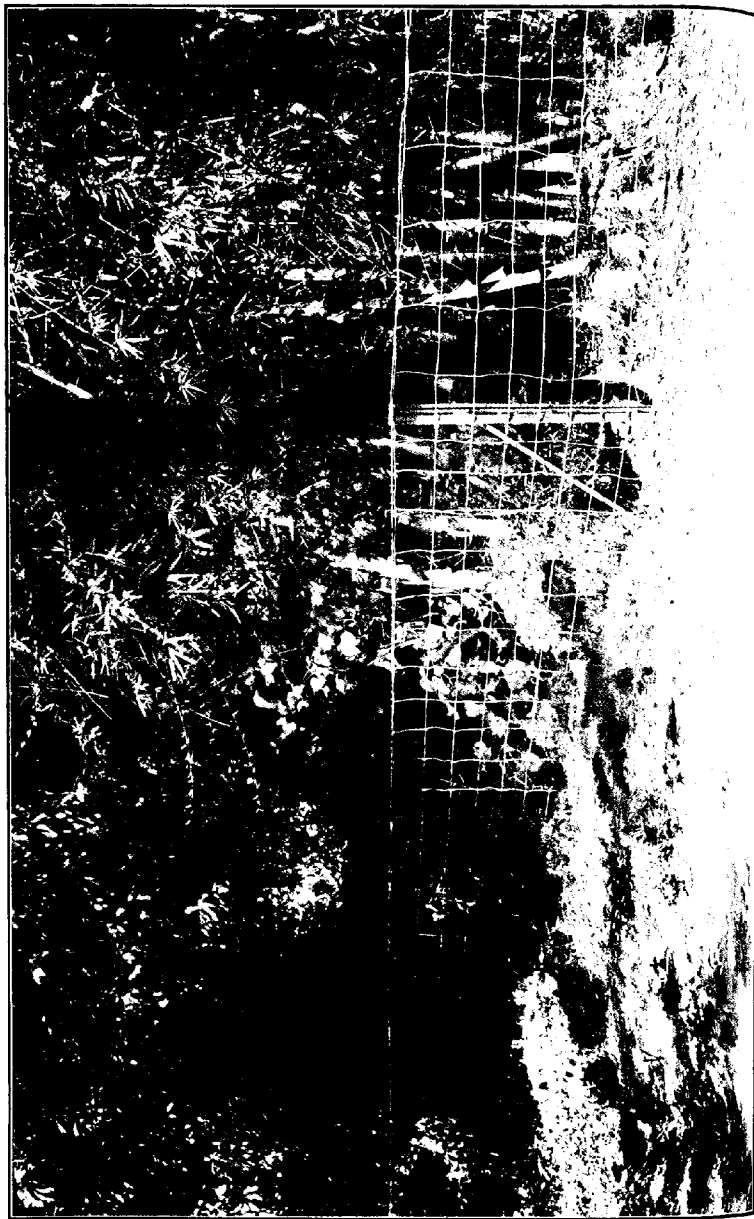
Agriculture and by means of these a few pig have been caught; but while the number destroyed by these different methods may total to some thousands every year, the number of young produced probably amounts to many hundreds of thousands. To obtain immediate and effective results in crop protection, therefore, the use of fencing is necessary, by means of which valuable crops in pig-infested areas can be saved from their ravages. To attempt to grow the thick juicy high quality canes which are so toothsome to pig from a porcine point of view would, in districts where pig abound, appear to be a hopeless task without some such precautions.

3. The types of fencing used locally for cane fields are all more or less inefficient and it is customary therefore to keep also a watcher at night in the fenced field. His wild yells in the silent watches of the night on the approach of "grunTERS" are generally sufficient to scare them away: but at times, Homer-like, he often nods, and on such occasions the owner finds next morning that thousands of his canes have been destroyed and that his farming profits have been very materially affected thereby.

Where wood is plentiful, it is usual to construct a fence of thorns or bamboos, but on the efficacy of such a fence one never can entirely rely, as both pig and jackal bore their way through it.

Where jungle is distant a mud wall about 3' in height is constructed all round the field; this is generally effective in keeping out pig if kept in a good state of repair; but jackals do not hesitate to jump over a wall of this height. Not only are the fences in common use at present inefficient but in the long run they are more costly than a *pucca* and permanent fence would be. To fence an acre with the branches of thorns or garari (*Cleistanthus collinus*) costs about Rs. 12 and lasts for one year only. In addition to this the owner has to meet the cost of retaining one watcher for 8 months and the practical certainty of a certain amount of loss. The cost of patent woven wire fencing per acre now under trial is about Rs. 200 and it should last for at least 20 years. Barbed wire fences are quite useless.

PLATE XXIII.



4. As the problem of protecting cane had become a serious one, I had occasion two and a half years ago to suggest to the firm of Messrs. Burn and Company that they might design a strong woven fencing of the type of wire netting. The firm in reply sent a roll of patent wire fencing known as the Ideal woven fence which had been sent to them on trial from home. Page's fence supplied by Balmer, Lawrie and Co., is similar in construction to Ideal fencing, but the wire is of a lighter kind. Of both these patent fences there are several types varying in height and in the size of the mesh. We have tried several of these in the Central Provinces and have found that a fence about four feet high with a mesh 3 inches in depth at the foot, increasing to six inches at a height of 2 feet is, if properly fixed, quite effective in keeping out pig. For general purposes type No. 1150 of Ideal woven fencing is, as far as I have seen, the most suitable. It is supplied in rolls of 220 yards and costs 8*d.* per yard run. The fence is 50 inches high, and has eleven strands with uprights 13 inches apart. It is sufficiently strong to keep out cattle, sufficiently high to prevent *nilgai* from jumping it and the mesh is sufficiently small to debar pig. If properly stretched, jackals cannot get through it without considerable difficulty.

Patent woven fencing is being successfully used as a deer fence for a park in the Maharajbag gardens in Nagpur in which *nilgai*, *sambar*, antelope and *cheetal* are kept.

The chief points to be attended to in constructing a fence of this kind are (i) to see that the lower edge is two or three inches below the surface of the ground, (ii) that there is no space left between the lower edge of the fence and the ground, e.g., at *nala* crossings, and (iii) that the wire is properly stretched. Nos. (ii) and (iii) are obvious points, but in the case of fences erected on our experimental farms I have noticed that the staff seem at first incapable of grasping their importance, and almost invariably leave an entrance somewhere. They only learn by sad experience that the habit of the pig on approaching a fenced field is to run along the wire in search of an opening. On several occasions pigs have got into our fenced areas by such openings, and their

destruction when inside has given a considerable amount of sport. A large boar, which recently entered, by a *nala*, the cane area fenced with Ideal woven fencing on the Raipur Farm, after having made many attempts to find an exit, charged and knocked down several coolies and one of the farm staff, and died inside the fence fighting to the last.

No. 1150 Patent Woven fencing described above costs 8 annas per yard exclusive of posts. In jungly districts where it is most required wood can be obtained at low rates and the cost of this patent fencing with wooden posts is approximately the same as that of an ordinary wire fence with iron standards. So as to obviate the necessity of having to renew these wooden posts after a period of years it will be found advisable to plant, between each pair, a cutting of *salai* (*Boswellia serrata*) or some other species which can be reproduced from cuttings. In two or three years these *salai* trees will serve the purpose of permanent posts. This method of fixing the wire is now being tried by the Department and will, I believe, prove satisfactory.

Semi-wild cattle, though of limited numbers and local occurrence, do an enormous amount of damage to crops in the vicinity of the jungles in which they live. The cattle live in herds of from 30 to 70 and there are few districts in the Central Provinces without one or two such herds. By day they are to be found resting in the jungle from which they pay nightly visits to the nearest cropped fields. These herds are no doubt the descendants of strays or of animals set loose as an act of religious merit by Hindus. They are generally in prime condition; are much more alert than domesticated cattle, and are often very furious when irritated.

To destroy these animals would offend the religious prejudices of the Hindus; to construct a fencing that will keep them out of a field is too expensive to be a practical proposition. The only feasible remedy left, therefore, is to capture them. Three methods of accomplishing this have been tried in these Provinces. The first was to entice these animals into a large *kheddah* strongly fenced with fencing of 8 barbed wires on

posts 4 feet apart, each supported by a stay to give it strength. The fence was interlaced, moreover, with thorny babul branches and a trench 3 feet wide and 3 feet deep was dug to prevent the cattle when inside from rushing it. The cattle were enticed inside by *juar* stalks placed inside. Trails of *juar*, salt and cotton seed leading up to the entrance were also put down. The area of 3 acres inside the *kheddah* proved much too large and great difficulty was experienced in approaching the enclosed cattle sufficiently near to lasso them. To throw the lasso for any considerable distance with effect was impossible owing to the number of obstructions in the form of trees. Moreover, when once enclosed, these cattle become dangerous and a man can only approach them in safety by taking shelter in a heavy cart with a hood. This was done and the lasso was thrown from the end of a long bamboo. Even after taking these precautions this method involves much danger for the lasso thrower who is not constantly on his guard. To manipulate the bamboo properly he has to come out of the cart and is liable to be charged at any time. While carrying out this operation for the first time two men were injured by an infuriated bull which charged and gored them. Over 30 animals were captured last hot weather in a *kheddah* of this kind, but we do not recommend it as the most suitable.

The second method that has been tried was to drive the cattle into nets placed in the more open part of the jungle. But this, too, was rather unsuccessful. The excessive exertion entailed on the animals in their efforts to escape resulted in the death of most of them from abortion in the case of cows in calf, and from what appeared to be congestion of the lungs in the case of other animals.

The third and most successful of the methods tried was to construct a very small *kheddah* 40 feet square, of strong wooden posts 3 feet apart and 7 feet high, with cross pieces 1 foot apart. To give this fence additional strength a strong stay was put in behind each post. The cattle are allured inside as described in the case of the previous method and the gate is then quietly

closed by the watchmen in charge. They are then lassoed one by one by men who have taken up their positions in trees overhead. Fifteen were captured in this way recently without much trouble. Plate XXIV shows how this was accomplished. This method is easily the cheapest and most expeditious that has yet been tried and will be adopted in capturing other herds that are still at large.

PLATE XXIV.



CAPTURING WILD CATTLE.

CONVOLUTED TUBE WELLS FOR IRRIGATION

BY

T. A. MILLER BROWNLIE, C.E.,
Engineer, Amritsar Municipality.

CONSIDERABLE difficulty is experienced in many parts of the country in obtaining a sufficient supply of water from wells for the necessary irrigation of the fields in their immediate vicinity.

Most people are aware that only a limited quantity of water can be taken from any well; this limited quantity, which is the safe yield of the well, represents a maximum velocity of water passing through the subsoil (sand, gravel, etc.) which forms the well floor, without disturbing the arrangement of the finest particles forming the flooring.

The velocity at which this disturbance commences is known as the "critical velocity" and this varies with different qualities of subsoil. For instance in a well sunk in gravel, the water passes through this material at a comparatively high velocity before the smallest pebbles are displaced, whereas, in a well sunk in sand, the critical velocity is much lower, the finest particles of that material being more readily displaced than small pebbles.

Water may be withdrawn from any well for an indefinite period without damage to the well, provided the critical velocity is not exceeded, but, if the rate of withdrawal of the water exceeds the critical velocity, the effect is as follows: the finest particles of sand at, and near the surface of the floor of the well are the first to be displaced, these will be in partial or full suspension, according to the velocity of the water; fine particles from the layer below the surface will travel upwards to replace the voids left by the particles from the surface layer, and these in turn will be carried into the well. This action extends below the

level of the bottom of the walls or curb of the well and also extends laterally; the fine particles flow in from under the walls, the density of the subsoil is being altered, the spaces between the particles of sand increased.

The disturbance of the subsoil is within a roughly shaped plano-convex figure, on the plane surface of which the well rests, and the superficial area of the whole figure (excluding the well area) is such, that the water passes through this surface at the critical velocity for the subsoil.

What then is the result of exceeding the critical velocity of a well? (a) The finest material is washed into the well and forms a new floor in the well above the level of the old floor, *i.e.*, silting occurs. (b) The subsoil under the well is loosened and the well tends to sink and is liable to collapse.

The principle of exceeding the critical velocity in wells is adopted for sinking wells for foundation work, powerful pumps being used to pump out the sand, gravel, etc., which flow into the well, thus loosening the foundation, into which the well sinks by gravity.

Various expedients have been tried in order to increase the yield of wells beyond their critical velocities, one of these is to fill in the floor of the well to a certain depth with gravel of various sizes, arranged somewhat in the manner of a percolation filter, but in reverse order, this has not proved satisfactory as after a short time the wells again become silted, by sand etc., being carried up through the interstices of the stones. Exactly the same feature is observed in ordinary water filters when worked too rapidly. Where sand of varying grades of coarseness forms the floor surface of wells it has been found that the fine particles are disturbed at velocities of $2\frac{1}{2}$ feet to 3 feet per hour, *i.e.*, the critical velocity.

Another method is to cover the floor of the well with a fine straining material, and this also has proved unsatisfactory on account of the finest particles of the subsoil being washed through the strainer and silting on its upper surface, while at the same time the coarser particles pack on the under side of the strainer

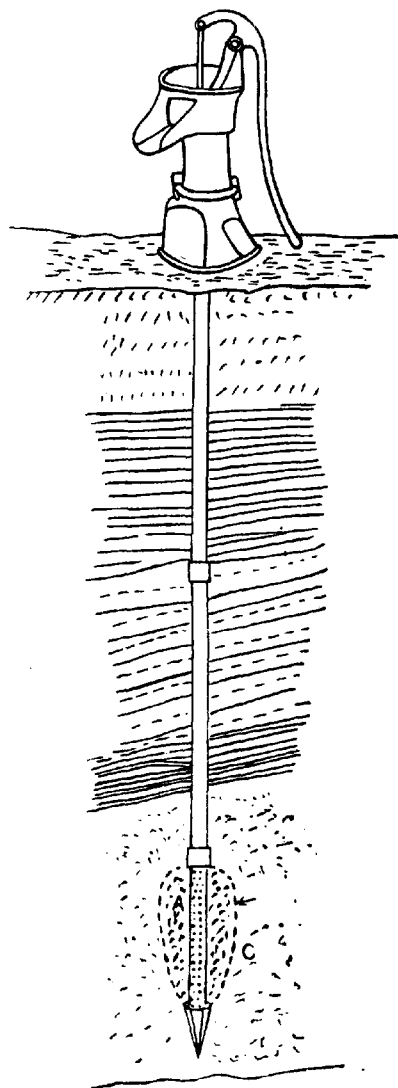
thereby reducing the flow until the yield ultimately falls again to the critical velocity.

Experiments on the yield of ordinary wells have been carried out for over 30 years by various engineers in many parts of the world, and the conclusions drawn from these are, that it is unsafe to withdraw water for any length of time, at a rate exceeding the critical velocity of the subsoil of the well. The critical velocity in sand of varying degrees of fineness has been found to be between $2\frac{1}{2}$ and 3 feet per hour, and even in coarse sand of fairly uniform grain, only a very slight increase in this critical velocity has been observed. The critical velocity in various qualities of sand being within comparatively narrow limits and loading and screening of the floors of the wells having little effect on their velocity; the question arose, why is it possible to extract a much larger quantity of water per unit time, area, from the Abyssinian and American forms of tube wells, than from ordinary wells in the same subsoil.

The writer has been investigating this subject for twelve years, and experiments carried out with tube wells of various forms in several conditions of subsoil, natural and artificial, have resulted in the conclusion that water may be withdrawn constantly from these tubes at a rate which represents a velocity through the water way area of the strainer of forty to sixty times the critical velocity of the subsoil. That is to say, if an ordinary well with floor area of one unit discharges one unit of water per minute under a head of six feet without exceeding its critical velocity, or say half a unit of water per minute when under a head of four feet, then a tube well in the same soil and having a straining waterway area of one unit, will deliver, when under the same head of six feet, from forty to sixty units of water per minute, or from twenty to thirty units per minute when under a head of four feet.

For purposes of illustrating the reasons for this, the Abyssinian tube well may be taken. This consists of about 20 feet of pipe say $1\frac{1}{2}$ inches diameter; one end of this pipe is perforated, for a length of a few feet, with a number of small

holes about $\frac{3}{8}$ inch diameter; over this perforated portion of pipe a straining material, usually fine wire gauze, is secured,



Abyssinian Tube Well.

A—"cavity" consisting of coarse particles of sand surrounded by C—unaltered sand.

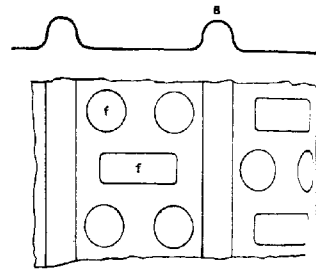
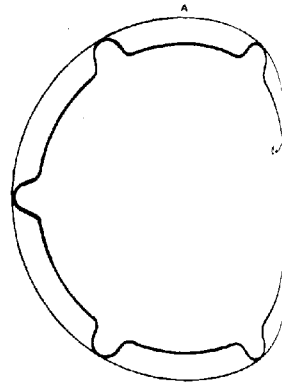
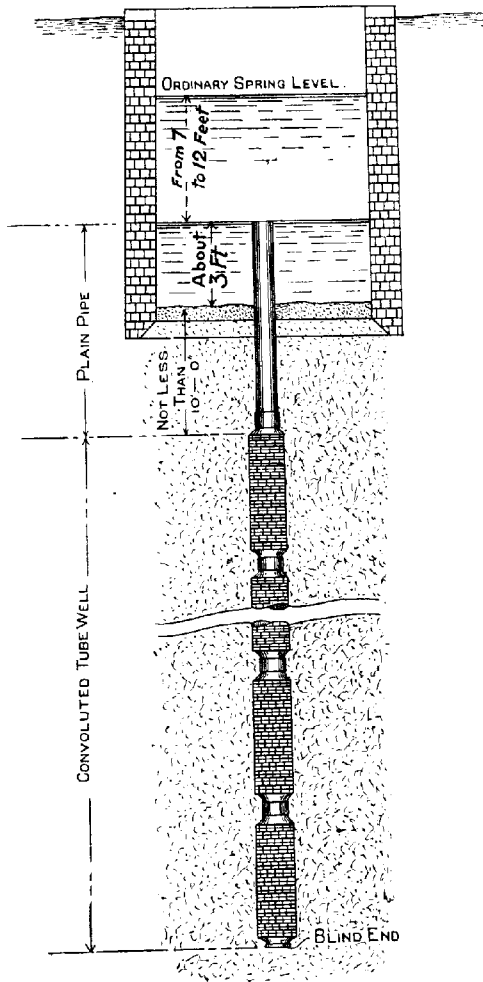
and over the gauze, in order to protect it from damage, a piece of perforated sheet metal is secured. The perforated end of the

pipe is closed, and provided with a metal point for driving into the ground. The whole length of tube is driven vertically into the ground, leaving only one foot or so above ground level: a hand pump is attached to the portion of pipe projecting above ground. This form of tube is of course only suitable for low lifts, *i.e.*, when the water level is about eighteen feet from the ground surface.

On working the pump, a mixture of sand and water is discharged and pumping is continued until the water comes away free from sand, and thereafter a constant supply of clear water may be obtained.

Now what has happened round the strainer or perforated portion of the tube is that the fine particles of sand have been washed through the straining material into the tube, and the tube being of small bore in comparison to the quantity of water passing through it, the velocity up the tube to the pump is sufficient to carry the sand with it, keeping the inside of the tube and strainer free from silting. The subsoil surrounding the strainer portion of the tube has become freed of its finer particles, and therefore has a higher porosity than the undisturbed subsoil; this freeing of the subsoil surrounding the strainer takes place within a pear shaped figure, the strainer tube being the axis: the surface area of the figure is such that the water passing through this surface has a velocity not exceeding the critical velocity for the subsoil. Therefore surrounding the strainer we have what is usually called the "cavity" which is only a cavity in the sense that it is freed from the smaller particles of sand and contains the coarser material loosely packed. The writer's experiments have shown that this coarse material arranges itself around the strainer according to size of grain, the largest being next to the strainer, then the second largest and so on to what might be called the critical velocity limit, where the disturbed merges into the undisturbed subsoil.

These Abyssinian tube wells give comparatively small discharges and owing to their construction do not last any great



A.—Cross section of convoluted tube well; (f) straining material.

B.—Piece of convoluted sheet before forming perforations in sheet.

length of time, but are extremely useful for domestic supplies and are inexpensive to repair. The fact that the straining material is in contact with the perforated portion of the tube, reduces the waterway area of these perforations by the amount of wire in contact with the perforations, this represents quite three-fourths of the area thus rendered ineffective.

The convoluted tube well which is designed for large discharges, differs from the many forms of tube wells on the market in so much that it is the only tube well which has the waterway area of the straining material equal to the waterway area of the perforations. The tubes are made from sheet steel, specially shaped to obtain this result, which prevents any change of velocity between the straining material and the body of the tube and thereby reduces friction and loss of head to a minimum.

The straining material is composed of heavy copper wires lying parallel, and woven with copper ribbons; this arrangement forms a substantial and lasting material combined with a maximum of fine slots for the percolation of water.

Convoluted tube wells are manufactured in various sizes for discharges ranging from 5,000 to 45,000 gallons per hour.

The method of sinking and working these tube wells is as follows:—If the tube is required to augment the supply of water to an existing well and the desired quantity of water from the tube well has been decided upon, a tube well estimated to yield the nearest quantity above the required amount should be selected. Now assume that the tube selected is 40 feet in length, then a bore tube of a few inches larger diameter than the diameter of the tube well should be sunk in the well to a depth of not less than 50 feet below the bottom of the well. The tube well is lowered into the bore tube, and sufficient plain pipe is added to the tube well, to bring the upper end of the plain pipe not less than seven feet below the normal spring level in the well; the bore tube may now be withdrawn and the tube well is ready for use. So long as the water in the well is not lowered more than would exceed the critical velocity for the material forming the well floor, there is no need to cement or otherwise seal the well floor,

the tube well will yield its supply in addition to the yield of the well.

In cases where the yield of the well is small, due to a small well, to the floor of the well being in a bad water-bearing stratum, or to other causes, it is advisable to seal the well floor with cement concrete, the water level in the well may then, if desired, be reduced below that level which would represent the critical velocity for the material forming the well floor, but, this lowering should not be carried to excess, or in other words, very little more water than the amount the tube is designed to discharge should ever be pumped from these tube wells. Overpumping causes the coarse particles which are too large to pass through the straining material, to pack against the strainer thereby reducing the porosity of the material surrounding the strainer and the discharge from the tube well is consequently reduced.

Convolute tube wells may be sunk direct into the ground and worked by attaching the pump to the upper end of the plain tube, the plain tube then becomes the suction pipe of the pump; this arrangement is particularly convenient where spring level is within the suction action of pumps worked on ground level. Considerable care should be exercised in fixing the pump level relatively to water level as various forms of pumps differ very considerably in efficiency on different suction lifts: generally the suction should be as short as possible.

In situations where the spring level is at a depth below ground surface too great for the suction action of a pump worked on ground surface, the pump may be placed in a chamber below ground level and within convenient suction distance of the reduced water level. For this reason it is often convenient to sink these tube wells in old wells, which provide space for the pumps or the small tubes may then be worked by Persian wheels or chain pumps.

Where the water level is very considerably below ground level, the Ashley tube well pump should be employed, and in order to obtain the full discharge of the tube well the plain tube should be of larger diameter than the straining tube.

The Ashley pump can be worked with safety in this tube to depths of several hundreds of feet below ground surface. In single pumping plants of this type, a water compensating balance relieves the weight of the pump rods; in the duplex sets, the rods of one set are balanced by the rods of the other set.

Tube wells which are worked by the Ashley pump should be carefully shrouded to prevent powdery sand from reaching the valves; shrouding is an advantage also in very fine sand or other low porosity subsoil.

Convoluted tube wells are manufactured for India by the Empire Engineering Company, Cawnpore, and are stocked with a standard gauge of straining material which is suitable for most places, but, it is advantageous to submit geological sections and samples of the strata met with, in order to obtain the tube best fitted to the conditions under which it has to work.

The smallest stock size of convoluted tube well, $3\frac{1}{2}$ inches diameter, will generally be found sufficient for increasing the water supply in wells in which Persian Wheels, or other forms of animal power water lifts are employed. These tubes are capable of delivering up to 5,000 gallons per hour, cost Rs. 272, and can be sunk and made ready for use for a further expenditure of roughly Rs. 200/-, or under Rs. 500/- in all. This sum is approximately one-eighth of the cost of ordinary wells of equal capacity, and in the larger sizes the difference between the cost of tube wells and wells of equal capacity, is much more marked.

Well Irrigation in India has varied little in the past and this is no doubt largely due to the limited supply of water which can be drawn from any one well. From observation made of over 40 wells in the Punjab, I have found that with one pair of bullocks working ten to twelve hours per day, the quantity of water lifted is 2,000 gallons per hour on 30 feet lift, and 2,500 gallons per hour on 25 feet lift. With improved chain pumps 2,400 gallons per hour can be lifted 30 feet by a pair of bullocks, and the rate for these with an attendant averages Re 1/- per day.

The cost of a chain pump or Persian Wheel and bullock gear suitable for this work is roughly Rs. 300, a well as built by zemindars may be taken at Rs. 1,000/- the total cost of the plant being therefore Rs. 1,300.

The annual maintenance is as follows :—

Interest on Rs. 1,300 at 4 %	...	...	Rs. 52/-
Depreciation of well only at 5 %	...	...	" 50/-
Depreciation of Persian Wheel at 10 %	...	...	" 30/-
Pumping cost, bullocks at 1/- for 365 days	...	...	" 365/-
<hr/>			
Total annual cost =		..	497/-
say Rs. 41/6/- per month.			

The quantity of water pumped per month is 2,400 gallons \times 12 hours \times 30 days = 864,000 gallons at a cost of Rs. 41/6/- or 1,305 gallons for one anna.

To put down steam or oil plant to pump such a small quantity of water would not be economical, but if a few zemindars combined and put down a medium sized tube well capable of yielding say 25,000 gallons per hour for a lift of 30 feet the cost would work out as follows :—

Water Horse Power, $\frac{417 \text{ gallons per minute} \times 19\text{lbs.} \times 30 \text{ feet}}{33,000} = 3.8$

Efficiency taken at 0.45, the H.P. required = 8.4

and the nearest size of engine is 9 B. H. P.

Oil consumption at 0.85 pint per B. H. P. per hour would amount to $\frac{0.85 \times 9 \times 12}{8} = 11.475$ gallons, and the cost of 125° kerosine oil for most places in the Punjab does not exceed 9½ annas per gallon.

The daily driving cost is therefore—

	Rs.	A.	P.
Oil consumption 11.475 gallons at 9½ annas per gallon	...	6	13 1
Lubricating oil 1 pint at Rs. 2 per gallon	...	0	4 0
Starting oil ½ pint at 9½ annas per gallon	...	0	1 3
Waste and sundries	...	0	1 8
Driver at Rs. 30 per month	...	1	0 0
<hr/>			
Total daily driving cost	...	8	4 0

COST OF WORKS.

	Rs.
Tube well sunk complete	1,600
Oil engine and pump	3,000
Engine house, driver's quarters and godown	1,000
Allow for sundry requirements	400
Total cost of works	6,000

ANNUAL MAINTENANCE.

	Rs.
Interest on Rs. 6,000 at 4 per cent.	240
Depreciation of tube well and engine at 10%	460
Depreciation of engine house, etc., at 5 per cent.	70
Daily driving cost at 8 4 x 365	3,011
	3,781

say Rs. 3,800 per annum

Therefore the quantity of water which can be pumped for one anna is 1,800 gallons or an increase of practically 40 per cent.

If the plant is put down in duplicate to allow for stoppages for petty repairs, etc., the annual maintenance would then be Rs. 4,550 or 1,500 gallons per anna, but with duplicate plant installed the engine could be run for longer periods by an additional driver, interest and depreciation would remain as before and a further reduction in cost effected.

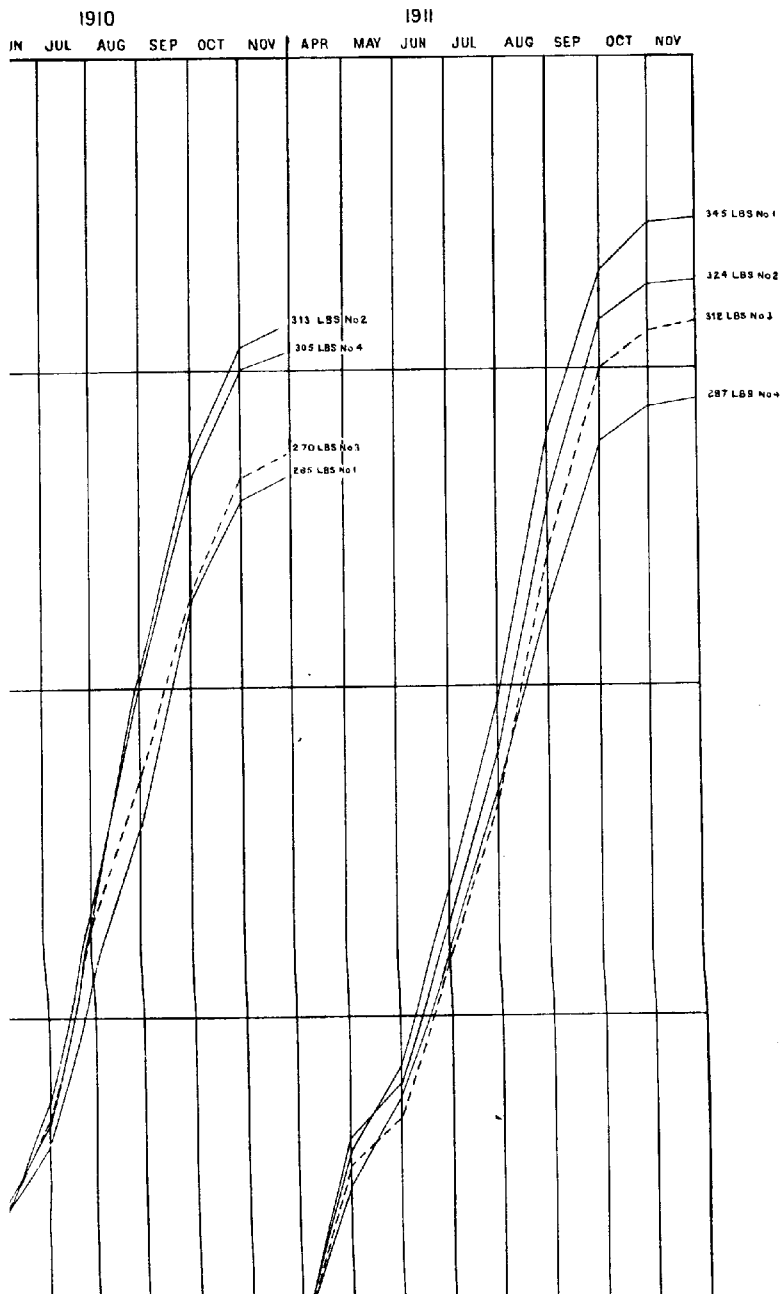
This estimate of cost of pumping is higher than the actual cost would be, as it covers allowances for wastage, etc. The writer has three installations at work and is shortly putting down a fourth of 40 B. H. P. These installations are of 6½, 9 and 32 Brake Horse Power, and are all worked on a less rate than estimated above.

It is essential to select the pump and engine best suited to the particular work it has to do, otherwise a considerable drop in efficiency and consequent increase of working cost will result.

When the larger sizes of tube wells are employed, engines consuming crude oil may be employed; this will cause a further saving of 20 per cent.

There is not the slightest doubt that by the use of tube wells worked with properly selected pumps and oil engines, lift irrigation can be effected at a rate very considerably cheaper than by any other method at present in use in this country.

There are already many convoluted tube wells working in the Punjab both for public water supplies and for irrigation purposes. One case in particular is worth mentioning. A well of ten feet diameter was sunk over thirty years ago, with the intention of installing a Persian Wheel for irrigation purposes; unfortunately the subsoil was a mixture of running sand and clay; a single bullock Persian Wheel dried the well in half an hour and recuperation took so long that the Persian Wheel was dismantled and the well abandoned after a sum of over Rs. 2,500 had been spent on it. The writer installed a $3\frac{1}{2}$ inch convoluted tube well and now 100 gallons per minute or 6,000 gallons per hour is being drawn from the well for irrigation purposes.



EXPLANATION OF THE DIAGRAM.

No. of plot (each measuring $\frac{1}{4}$ acre).	MANURE APPLIED.		
	1909.	1910.	1911.
1	Castor meal, 15 maunds per acre.	Castor meal, 4 maunds per acre. Nitrate of potash, 40 lbs. per acre. Superphosphate, 120 lbs. per acre.	Castor meal, 4 maunds per acre. Nitrate of potash, 40 lbs. per acre. Superphosphate, concentrated, 60 lbs. per acre. Sulphate of ammonia, 120 lbs. per acre.
2	Green manure only, not dug in, only sickled when mature.	Green manure only	Green manure only.
3	Castor meal, 7 $\frac{1}{2}$ maunds per acre.	Nitrate of potash, 40 lbs. per acre. Superphosphate, 120 lbs. per acre.	Animal meal, 2 maunds per acre.
4	Nothing (check plot)	Nothing (check plot)	Nothing (check plot).

EXPERIMENTS IN MANURING ON A TEA ESTATE IN DARJEELING.

BY

CLAUD BALD,

Manager, Tukear Co., Ltd., Darjeeling.

It is impossible on a hill garden to find a continuous block of land where the quality of the soil is exactly equal over any considerable area, as the undulations of the land of necessity divert some of the best constituents of the soil into the hollows from the ridges, more or less, during heavy rain.

The block which was selected for these experiments seemed to all appearance as nearly equal in quality throughout as it was possible to obtain; and yet the event proved that there was some difference in favour of one side. The land was carefully measured, and the straight lines of tea bushes made it easy to plot off accurately four plots, each measuring half an acre. They were numbered from one to four. The land is slightly better in the direction of No. 4, which has been kept as the check plot. In regard to cultivation, pruning and plucking, all the plots have been treated exactly alike; so that the experiments might determine the results of the manuring only. The experiments were continued for three years. The diagram opposite and its explanation indicate the treatment and the resulting crop of tea for each year. The cost of manuring is shown on page 160. It will be noted that no farmyard manure has been experimented with; the reason being that on the estate no grazing is permitted, and there are very few animals kept, hence natural manure is not available in any considerable quantity, and it has become necessary to consider whether chemical or artificial manures can be applied in such a way as to prove remunerative.

In the first year the object was to find out whether the application of *castor meal* would give any encouraging result. An exceptionally heavy dressing was given to plot No. 1, while half the quantity was given to No. 3, and No. 2 was treated with *green manure* only. The green manure was a crop of *dal* similar to what is known as "*Mali Kalai*." The crop for the year was largest from No. 4, the untreated plot, indicating that the castor meal had practically no effect upon the outturn, while the better soil in the direction of No. 4 asserted itself.

In the second year Nos. 1 and 3 were treated with *chemical manure*, but *without nitrogen*, except the small quantity contained in the castor meal on No. 1. The nitrogen was purposely omitted, as it was feared that this manure would tend to the production of rank leaf, making coarse tea. No. 4 was again almost the highest in quantity of produce; but it was beaten by No. 2, which had been treated for two years in succession with green manure only.

In the third year No. 1 was treated with a *complete chemical manure*, with the addition of a small dressing of castor meal. No. 2 again had *green manure* only; while No. 3 had an application of *animal meal*. The nitrogen applied to No. 1 (in the form of ammonia), sent up the crop from that plot to the highest point; but it was closely followed by No. 2, which made an increase on its previous record. The check plot made rather less tea than in the previous year.

Some of the outstanding facts in connection with these experiments are the high cost of chemical and artificial manures in a remote district like Darjeeling, and the extreme doubtfulness of their economic utility; also the possibility of using expensive manures while accomplishing practically no result, in consequence of the manure used not being of a suitable composition: then there is the special outstanding fact that while green manuring is the cheapest method, it produces remarkably satisfactory results. It may be noted that the manures were used in one application only, as the nature of the ground was such that it was not advisable to dig at all during the rainy season, for fear of losing soil by wash.

An important fact in connection with the green manuring is that the crop was not dug into the land in the green state. It was only sickled when it came to maturity, and left as a mulch upon the ground until the rains were over, when the rotting stuff was dug in. At the same time a similar quantity of ordinary jungle growth was dug into each of the other plots. It is probable that the rotting leguminous crop contained a larger proportion of nitrogen than the rotting jungle; but in any case it seems that the special benefit which accrued to plot No. 2 may be chiefly attributed to bacterial action on the roots of the leguminous crop.

The relative amount of crop having been determined as a result of the manuring, it remained to be seen whether there was any difference in the quality of the teas produced under the different circumstances. This is indeed the most important consideration of all on a hill garden, where the quality of the teas must of necessity be the first consideration. With a view to determining this a set of samples was carefully prepared from each plot, and reported upon by an expert. The valuations were $10\frac{1}{2}d.$, $11d.$, $9d.$ and $1s.$ per lb. of samples made from plots 1—4 respectively on 18th September 1911. It has been felt, however, that in order to determine the real relative value it is necessary to have a series of samples drawn from the plots at stated intervals throughout the manufacturing season, as it is well known that some of the chemicals are so evanescent that their effects upon the teas may be very great in the earlier part of the season, while other ingredients which only become absorbed by the plant after some months may have a very different effect upon quality towards the end of the season.

A digest of the results for the three years in crop and cost is as follows :—

Tea per acre in Plot No. 1 ... " No. 2 ... " No. 3 ... " No. 4 ...	1909.	1910.	1911.	TOTAL.
	lbs.	lbs.	lbs.	lbs.
Plot No. 1 ...	247	265	345	857
" No. 2 ...	239	313	324	876
" No. 3 ...	258	270	312	840
" No. 4 ...	275	305	286	867

The cost of treatment works out as follows :—

	1909.	1910.	1911.	TOTAL.
Plot No. 1 ...	Rs. 64 0 0	Rs. 33 6 0	Rs. 44 9 6	Rs. 141 15 6
„ No. 2 ..	„ 4 9 0	„ 4 9 0	„ 4 9 0	„ 13 11 0
„ No. 3 ..	„ 32 0 0	„ 16 6 0	„ 15 14 0	„ 64 4 0
„ No. 4 Check Plot; no expenditure.				

The total crop from No. 4 is comparatively high, because it stood relatively so high in the first year. Apart from the question of the relative quality of the teas produced, it will be seen that the extra crop from No. 3 is not sufficient to pay for the treatment which was given to it, while the cost of treatment to No. 1 is altogether prohibitive.

The valuation of the samples places No. 4, the untreated plot, much higher than any of the others, while the green manured plot comes second, and the plot treated with animal manure is given a very low place. It may be remarked again, however, that the valuations, for the reason above mentioned cannot be regarded as final.

WAYS AND MEANS OF INDIAN AGRICULTURAL DEVELOPMENT.

BY

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THOSE who are engaged in attempting to improve Indian agriculture—to assist the Indian ryot to get a better living,—are constantly being confronted with the difficulties due to his immediate poverty and the low economic condition of the country generally. Capital in India is scarce and interest high, and while the prices of agricultural products are low, the paraphernalia necessary for any marked improvement of system are relatively expensive and their maintenance in good repair is a constant drain.

It must be admitted that as far as the low profits of agriculture in India are due to these causes, the efforts of the Agricultural Department can do little except assist in creating a market in India for implements and manures, and so effect some reduction in their cost. The main activities of the Department hitherto have been in this direction and in that of improving and standardising seeds and popularising the best existing methods of cultivation. But the limit of improvement in these directions is a definite one, and the Indian cultivator using the best implements and seed on the best system will not be very much better off than he is now unless his scope of usefulness can be extended so as to multiply the produce of his labour manifold.

The degree to which such extension would have to take place in order to place the Indian on a level with the European or American agriculturist, is perhaps best illustrated by

a comparison of the wages of the Agricultural labourer in these three countries ; from which it appears that the Englishman is at least four times, and the American eight times as effective as the Indian labourer.

It is often carelessly assumed that this varying effectiveness is chiefly or even entirely due to racial and climatic differences and that little can, therefore, be done in any limited time to raise the effectiveness of Indian labour. But a little consideration will show that there is another factor which must have, quantitatively, a far greater effect on production than questions of race and climate : and that factor is the extent of the control of physical energy exercised by the labourer. The main sources of such energy are, the food of men and animals, wind, falling water, coal and oil : the history of civilisation, from the dynamic point of view, is the history of the progressive extension of man's control from that of the relatively small quantity of energy contained in the food he eats to that of the greater, but still not—per head of population—very much greater amount represented by the present consumption of the fodder of draught animals, of coal and oil and of the power derived from waterfalls and the wind. The labourer using his own strength only, however ingenious the implement with which he works, controls, though perhaps very efficiently, only the energy contained in the food he eats—represented approximately by the heat given out by the same amount of food if dried and burnt. The driver of a team of oxen or horses controls, in addition, the amount of energy contained in the food of his team ; while the driver of a steam traction engine controls, even though with comparatively small efficiency, the relatively enormous amount of energy contained in the coal burnt. And the results of the labours of the communities typified by these men, and ultimately the rate of wages in each, will be correspondingly, though of course not proportionally, great. One could venture, for instance, to assert with some confidence that in different agricultural districts of India, the rate of wages would be found to vary generally with the size of the bullocks—or rather with the weight of the team—

customarily used for draught purposes, and there is no doubt that the American farmer can afford to pay his men a wage of a dollar a day mainly because of his efficient system of using horses.

This being so, the problem of increasing seriously the prosperity of the Indian ryot becomes one either of increasing the weight of his team of cattle, or of providing him with a more powerful agency for doing his work. Taking the question of cattle first, it is clear that the argument so often advanced against the introduction of new implements which, though essentially more efficient than those now in use, are also heavier to pull—the argument that they need a heavier team to pull them, is one that really tells in favour of the new introduction; for in addition to the increased efficiency of the implements, they enable the driver to find a use for greater cattle power, and so increase his productive capacity. It would almost always be possible for the owner of even a small holding so to increase the produce of his land by better cultivation or irrigation as to provide the additional amount of fodder for larger bullocks if he could not reduce their number. But in any case the smallness of existing holdings could nowhere prove a permanent bar to economic advance.

There can be no cavil then at the attempted introduction, in any district, of implements which only the heaviest bullocks available can draw—provided that the implements are efficient in themselves, their size is all to the good and will increase the demand for the larger bullocks required to draw them.

The use of large numbers of bullocks in one team, as in South Africa, is a question almost of a different order, requiring an accumulation of capital in the hands of enterprising and experienced farmers such as hardly exist in India: and probably also the stimulus of a scanty population. It may even be conceded to the pessimists that the preliminary training and management of large teams would require more doggedness than a race bred in the enervating climate of India could command.

We are brought then to the question of the possibility of substituting some more powerful agency for bullocks in Indian agriculture.

Among animals, experience seems to show that the horse is the best, being both stronger and more adaptable than the bullock, but the blood temperature of the horse (100°F.) is slightly lower than that of the bullock (101°-102°F) and, with the thermometer in the neighbourhood of blood heat, and a moist atmosphere, any such difference must make some difference in the cooling capacity and consequently in the efficiency of the two animals, because an animal becomes incapacitated if its temperature rises even a few degrees above the normal. It is, therefore, improbable that the horse, or any animal with a lower blood temperature than the bullock would prove an efficient substitute under Indian conditions.

This difficulty, of the approximation of the atmospheric temperature to that of the blood of animals under conditions that retard evaporation from the skin and consequent cooling, gives quite a special importance to the question of the use of mechanical means for controlling energy in tropical and subtropical climates. The efficiency of a steam or oil-engine is comparatively independent of atmospheric conditions, whereas that of an animal, depending absolutely on its capacity for immediately getting rid of the waste heat generated in the performance of its work, becomes rapidly less as the wet bulb thermometer rises.

It seems then that if the economic efficiency in agriculture of the inhabitants of India, and other countries where a considerable proportion of the work has to be done under conditions of excessive heat and moisture, is to be raised to anything like that of the inhabitant of the temperate zones, it must be by the substitution of mechanical for animal agencies for the bulk of the farm work. There is thus every reason to encourage the use of engines for such work as cultivation and transport, and the question of how they can be generally introduced into India is one of considerable interest.

The conditions favourable to the use of ploughing and traction engines are, firstly, large areas of open land, secondly, cheap fuel, and thirdly, capital. All these are already to be found in the Gangetic plain from the United Provinces to Assam, and

there should be every chance of success for any landowner in that region taking up the problem seriously, particularly in connection with the growing of sugarcane for which deep cultivation is profitable and the area of which is usually limited by the available labour supply.

But in many districts the occupation of numerous small areas of land by ryots is likely to prove a serious obstacle to the formation of the large spaces required for mechanical cultivation, and in such districts its introduction will have to be left to the comparatively slow operation of economic forces, assisted perhaps by the spread of the co-operative idea.

And it is interesting to consider how the present trend of the world's economics is likely to affect this question. We have during the last century experienced an enormous expansion of the amount of energy available for man's use. Immense areas of land have been opened up in America, Africa and Australia, providing both energy in the shape of supplies of fodder for an unprecedented proportion of draught animals for agricultural work, and a field for them to work in. At the same time mechanical science has come into being and immense reserves of fuel have supplied the energy for innumerable engines. The big waterfalls of the earth have also been harnessed for industrial purposes. Thus a new standard of living has been set up among the western nations: everything, including energy itself and the means of controlling it, has become easier to get, the machinery of production—capital—has become commoner, and wages are rising all round.

Now although the end of the reserves and supplies of energy is not yet in sight, a large proportion of the face of the earth has already been exploited, while, comparatively, a small proportion of the population have as yet grasped the advantage of the greater scope thus offered. Only recently comparative freedom from universal financial and industrial crises has been guaranteed by the placing of the gold supply of the world on a broad industrial non-speculative basis, and with the growth of capital it seems probable that the European nations have now crossed the

threshold of an economic expansion which, in bringing the new standard of living within reach of all, will rapidly appropriate all the visible supplies of energy to their use. The world is in fact apparently now coming face to face with an appreciation of available energy limited only by its utility as measured by the results it will produce. Food, fodder and fuel are again becoming relatively more valuable and will be economised and eked out so as to produce the maximum possible result from the minimum expenditure of the only thing that is really ever expended—the value of which lies in its expenditure—energy. This must, in the absence of the discovery of sources of energy of a higher order of magnitude than those now known, produce a continual appreciation of energy—food, fodder and fuel—in terms of the products of its application. Owing to increasing economy the same quantity of energy will produce more and exchange for more of the durable things typified by gold; coal mines, oil-wells, waterfalls, land, will continually rise in value.

But this economy will only be effected by more and more perfect and elaborate organisation; energy will only be worth more because it is more intelligently and economically spent; as the value of energy rises, so will the value of organisation and intelligence, the solitary worker with little capital will be worse off than before because he will have to pay more for the energy he requires and will produce relatively less than members of larger and more perfect organisations. The backward farmer will go to the wall as his assessment for rent or revenue rises, and the small holder will have every inducement to join a larger organisation either by co-operation or by selling his holding and getting employment from others.

Under such circumstances, it seems probable that bullocks will ultimately give way to engines everywhere in the cultivation of the plains of India and that the population will find a use for the larger amount of energy they will thus control in elaborating agricultural and forest products to a greater and ever greater degree. Cotton mills, oil mills, sugar and alcohol factories will grow up in the midst of the large spaces from which they will

draw their raw material and probably their fuel. If in the process the cow gives place to the goat or the sheep, and the ryots' fields dwindle to gardens, is not this prospect better than that of congestion in large cities and desertion of the countryside such as has been fostered in other countries by the concentration of the expenditure of energy in large towns? Thus if the dream that many love to indulge in—of the small holder in his separate allotment,—depends for its realisation on a perfection of the means of distribution of energy and its control in relatively small units, which will no doubt come in time, but is too remote to be of immediate practical concern in a country where fuel is so scarce and badly distributed as in India; yet in her fertile plains there seems to be a prospect of an industrialisation that does not imply congestion.

Meanwhile the immediate requirements are capital and the engineer; and those whose efforts are directed towards hastening the introduction into the field of Indian agriculture, of these indispensable items of equipment, have the satisfaction of feeling that they are going with the stream and not too far in advance of the main tide.

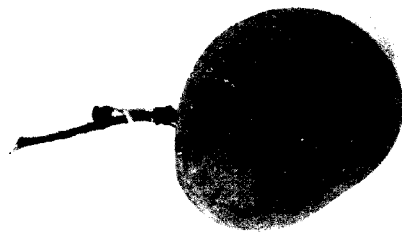
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Since the above was written, the following note issued by the Bombay Government has appeared in the press :—

“For some time past the Agricultural Department has been investigating the question of introducing mechanical traction for ploughing and other operations of cultivation. The question is becoming more and more important owing to the growing scarcity of fodder, cattle and labour, besides hand-digging being an inefficient means of clearing the soil of weeds. The Bajac windlass plough, drawn by bullocks, has now been introduced, and there is a rapidly growing demand for its use, but progress is slow as it works at a rate of one-fourth acre per day, and, in view of the enormous areas of weed-infested lands that require deep ploughing, steam traction was absolutely necessary. A scheme was accordingly prepared and submitted to the committee of the

Sir Sassoon David Trust Fund, who provided funds for obtaining a double engine steam ploughing plant. It is expected that this plant will plough 8 acres per day, at a cost of rupees seventeen per acre, about half the cost of the Bajac plough. In sugarcane tracts the introduction of the steam plough promises excellent results as the soil requires deep cultivation during the dry season, an operation which under existing conditions puts the cultivator to great expense."

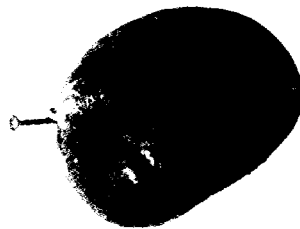
PLATE XXV.



GOL APOOS.



KALA APOOS.



ALPHONSE (BOMBAY).

THE ALPHONSE MANGO.

BY

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Bombay Agricultural Department.

THE Alphonse (commonly called Apoos) mango is one of the most highly prized fruits of India. It has been called by some the "Prince of Mangoes." Mr. Woodrow in his book on Gardening in India mentions that it is universally admitted to be the finest of all varieties of mango. In the Journal of the Royal Horticultural Society, page 755, Vol. 26 (1901-02), Maries has made mention of the Alphonse mango and regards it as the most delicious fruit and a general favourite. Personally I prefer this to all other varieties, as it excels others in every respect, though to some the taste is not so agreeable as that of the Pairi.

Regarding the origin of the Alphonse, there appears to be still a doubt. Maries says that this variety originally came from Salem in Madras Presidency and is now generally grown in Bombay gardens. But its original home seems to be Goa as the name Apoos (a corruption of the Portuguese name Alphonso) indicates, whence it must have been spread by man.

Though it may be supposed to have come originally from Goa the Bombay Alphonse is inferior in every respect to the Goa Alphonse. The Bombay Alphonse is smaller in size and scarcely weighs more than 350 grammes, whereas the Goa Alphonse weighs from 375 grammes and upwards, and is more delicious. The Goa Alphonse has a left shoulder higher than the right and has a slightly perceptible beak, but the Bombay variety is almost entirely lacking in the beak. (See Plates XXV and XXVI.)

The Goa Alphonse has been said to be the true Alphonse. To what circumstances its superior merit is due, whether to any peculiarity in the soil or climate, is hardly possible to decide. But this excellence in fruits in favoured localities is not confined to the mango. It is found in connection with most fruits in many parts of India.

The skin of the Goa Alphonse is greenish yellow with reddish orange on the exposed shoulder. In measurements it is $9 \times 6 \times 4.5$ cm. in the sample that I took. Though to some the taste is not superior to that of Pairi, its value is greatly enhanced by its keeping quality. A true Alphonse can be preserved for at least a fortnight after it is ripe and hence can be safely sent to foreign countries when it is unripe but fully developed in size. Its cultivation is now extending as it finds a ready market in many places. We find this variety the most frequent in almost every private gentleman's garden.

In the Bombay market, the bigger sorts of true Alphonse varieties of Goa are occasionally found, but these are sold very dear, sometimes as extra special quality. In favourable seasons they are sold from Rs. 2-8 to Rs. 3 a dozen; whereas in 1912 they were sold at Rs. 6 a dozen. In some parts of Goa, they are sold at the rate of 11 to 14 rupees a hundred, whereas in favourable seasons they are sold at Rs. 6 to 9 per 100. The price, however, fluctuates, according to the markets and according to the seasons of the year.

Many of the Mankurad varieties of mangoes found in Goa, are sold in Bombay as Alphonse. This is a variety nearly allied to Alphonse and closely resembles it in all respects except in size. It is a smaller fruit like the Bombay Alphonse. (See Plate XXVII.)

Sub-varieties.—There are three sub-varieties of Alphonse, viz., Gol, Kala and Kagdi Apoos.

Since I could not get the Kagdi Apoos I shall describe here the other two varieties. Kala Apoos:—The fruit has the flavour of Apoos. A few months old bark of this tree is dark in colour. The leaves are also dark green in colour. Owing to



ALPHONSE MANGO TREE.



LEAF OF THE ALPHONSE MANGO TREE.

these peculiarities, it is named Kala Apoos. The beak is prominent in this variety.

Gol Apoos:—It resembles Alphonse in all respects except the shape which is round more or less and hence the name Gol Apoos.

Characteristics of the tree and leaf.—The leaves of the Alphonse vary very much in size. In a good Alphonse tree, the leaves are dark green, with a white midrib. Mr. Woodrow mentions that among the choice varieties, the leaves of Alphonse may be known by the bright red midrib apparent until the leaves are nearly ripe, but I have rarely seen this.

In a collection of trees, it is extremely difficult to distinguish the Alphonse trees by the leaves and the nature of the tree only.

The smell of the leaves has been considered by some as one of the distinguishing features of identification, but this too sometimes fails. The tree is rather stunted and rarely approaches graceful symmetry. The tree is not very hardy.

The tree shown opposite is nearly seven years old. The above description applies to the Bombay Alphonse, whereas the Goa Alphonse trees are free growing and of monstrous size, attaining the height of 60 to 80 feet and even more and bearing profusely sometimes as many as ten thousand fruits, thus proving what a tree can be like, when situated in favourable localities both as regards soil and climate.

MANGO CULTURE IN GOA.

BY

S. H. PRAYAG, B.A.G.,

Bombay Agricultural Department.

OF all the edible fruits that are found in the Bombay Presidency, the mango ranks as one of the best and sweetest. In point of taste and colour, there hardly seems to be any fruit that can excel it. It seems, therefore, no exaggeration to say that it is the choicest fruit of India. It has been alluded to by Lady Brassey as the "King of Fruits." Its culture in Goa, the reputed home of the grafted mango, cannot fail to be of interest.

The distinction that Goa has acquired as a mango centre is due principally to the large number of excellent varieties grown there. There are few parts of the Bombay Presidency where the mango grows to such perfection, where it enters more widely into commerce and where the whole industry has thriven more and has contributed to the welfare of a greater number of people than in Goa. It is the heart of this industry. The plantations are located near the creeks and sometimes extend into the fertile plains and up the slopes of the hills. Here the climate is hot and moist, and as a steamy climate is congenial to the growth of mango trees; they have been found to grow to perfection, bearing a luxuriant crop.

Soils.—In Shivoli, Kanyasu, Parsem, Mapuca and Thorla Goa the mangoes are found to grow on two kinds of soil, *viz.* sandy and red laterite soil. Intermediate stages of these soils are also found to grow mangoes; but the best mangoes are grown in laterite soils and the soil that is not so very useful for the coconut, is reserved for mangoes.

Cultivation.—There is no regular cultivation followed anywhere in Goa, but huge trees are found to grow indiscriminately mixed with coconut, which forms the principal crop. The mangoes are grown from seeds and when they attain the age of 4 to 6 years they are grafted by the side method of grafting, which I shall describe here :—

At first a transverse cut $1\frac{1}{2}$ " to 2" in length is made in the stock at a distance of 9" to 1' from the ground. Above this a triangular notch 2" to 3" in length is cut out. The chief object



FIG. 1.—Method of side grafting, showing the triangular cut and the insertion of scion.

of cutting this notch is to stop a small portion of the ascending sap, in order that it may be absorbed by the scion. When a triangular cut is thus obtained, a longitudinal incision in the middle of the horizontal cut is made and is carried downwards very carefully up to the length of 4" to 6" according to the strength of stock and scion. The bark is then loosened for making way for the scion of the desirable variety. This is generally done by means of a small piece of hard wood cut in the form of the scion, as the instrument is frequently insufficient

for raising the bark. Care is taken not to bruise the inside wood. The scion is then inserted in the opening made for it and is gently pushed down till its shoulder rests on the top of the stock (Fig. 1). Further treatment is just the same as for other kinds of grafting. After two or three months when the graft has taken, the earth is heaped over the grafted portion, the head of the stock is topped off and only the scion is allowed to be seen. Watering is given every alternate day, if there be no rain and is continued for about 6 to 8 months, till the graft becomes sufficiently established.

Its advantages.—This method of grafting has advantages in the following respects :—

(1) It can be used to improve country mango plants growing in fields.

(2) Since the graft can be made upon a well-established country stock, the root system of which is well developed, the resulting grafted plant grows to a great size and bears profusely, besides lasting for a good number of years.

(3) Two or three or even five scions can be placed on one stock, so that if one does not succeed the others may thrive.

(4) It can be used on stocks up to $3\frac{1}{2}$ to 4 feet in thickness provided the bark does not split.

(5) Two or three scions of different varieties can be inserted, so that we can get two or three good varieties on one plant.

(6) If the graft does not take, the original tree does not suffer in any way.

(7) The percentage of success by this method has been said to be greater than by others.

Conditions necessary for ensuring success :—

(1) The operator must use stocks which are in the condition of flush, *i.e.*, with the sap flowing freely.

(2) He must choose fresh and one year old scions with terminal buds just swelling. The scions should not be shrivelled and all unions made should be well fitting.

To ascertain the right condition of the sap in the stock a slit is made in the bark of the stock, at some little distance

above the point where the graft is to be placed and observation made if it separates very easily from the wood. If it will not separate, the operation may be postponed.

(3) When separating the bark from the stock no injury should be done to the inside wood. It should never be bruised.

(4) The stock should not be topped until the graft is finally established.

Manuring.—Systematic manuring of the mango is not practised. The only manure that is in common use is salt. This is applied at the rate of one basketful per tree, when the tree attains the age of 3 to 5 years. It is then used once in 3 years and is applied on the surface before the rains, just near the trunks of trees.

Diseases.—It is subject to all the diseases that are found in Poona. *Ioranthus* abounds on the trees and no care is taken to remove it. "Black stem" (*Rhinoecidium corticolum*), *Cephaeleuros virescens* and "sooty-mould" (*Capnodium* sp.) are found. Removal of old decaying branches is not done at all and the trees are left to the tender mercies of nature. Even with all this struggle against diseases, it is surprising to note that the trees are very prolific bearers and fetch a considerable price.

Varieties.—The numerous varieties that are found here vary in quality, flavour, juiciness, and succulence of the pulp, size and shape of the fruit, etc. Some have a very pleasant and piquant taste, while others are delicious with a slight turpentine flavour and stringiness. The quality largely depends on the proportionate size of the stone to the amount of pulp, on the absence of fibre and on the taste and lasting quality of the fruit.

For convenience sake I shall describe here only four select varieties, dealing with others in a separate paper. These are—

Goa Apoos, Mankurad, Fernandin and Maldez.

Size and weights are averaged from two typical fruits in each case.

Goa Apoos.—Weight 385 grammes; size 10·9 × 8·5 × 6·5 cms. General appearance—greenish yellow with small glands on the surface, beak very scarcely perceptible; left shoulder

higher than the right. Pulp and taste—yellowish, very sweet and piquant; no fibre—an excellent and much appreciated fruit. (Fig. 2, Plate XXVII.)

Mankurad:—Weight 226 grammes; size $8.6 \times 6.5 \times 5.2$ cms. General appearance—left shoulder very slightly higher than the right; thin skin firmly attached to the flesh; beak absent. Pulp and taste—yellowish, very luscious; no fibres. (Fig. 3, Plate XXVII.)

Fernandin:—Weight 334 grammes; size $10.2 \times 6.5 \times 5.2$ cms. General appearance—fruit longer than broad; small glands present; surface rough and warty; slight prominence below left shoulder, bright red on exposed side and yellowish-green on the non-exposed side; thick skin closely attached to flesh. Pulp and taste—bright yellow, thick, very luscious, a very superior sort. (See Plate XXVII.)

Maldez (Pokal):—Weight 256 grammes; size $10.7 \times 6 \times 5.2$ cms. General appearance—greenish yellow, tinged with bright red on exposed shoulder; very slightly inverted beak.

Pulp and taste—orange red, sweet, distinct and agreeable flavour, slightly fibrous. (See Plate XXVII.)

Methods of disposal and marketing of fruits:—The grower sells his fruits usually through a broker. The broker acts as an agent for both the parties. It is sold by the grove as a whole for the season, the purchaser taking all the fruits, or each picking is sold separately by 'hundreds,' a 'hundred' meaning 130 in some parts of Panjim Taluka, whereas in Mapuca Taluka it means 105. In some regions of Mapuca Taluka where the mangoes are finer in grade and better for export owing to steamer communication, they are sold by true hundreds. Mango-growing for the market is a very profitable undertaking in some parts of Goa where they are grown as an industry. A considerable number of Apoos and Mankurad varieties are sent to Bombay markets through a broker—Maldez, Fernandin, Mankurad and Collace varieties are sent to the markets of Belgaum, Dharwar and Hubli, when steamer communication to Bombay is stopped.

Scale centimetres.

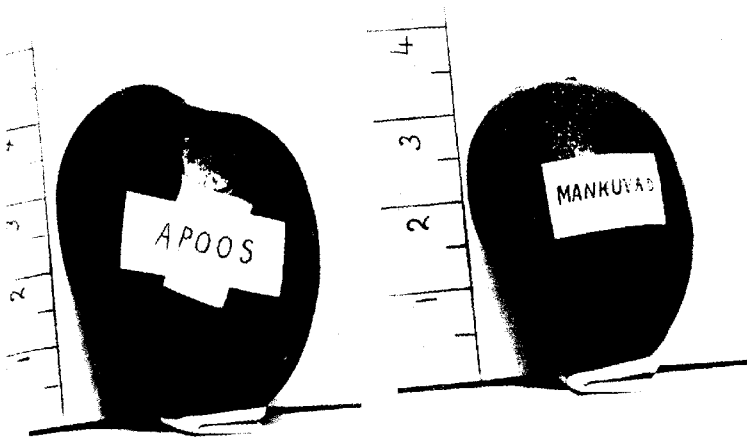


FIG. 3.

FIG. 2.

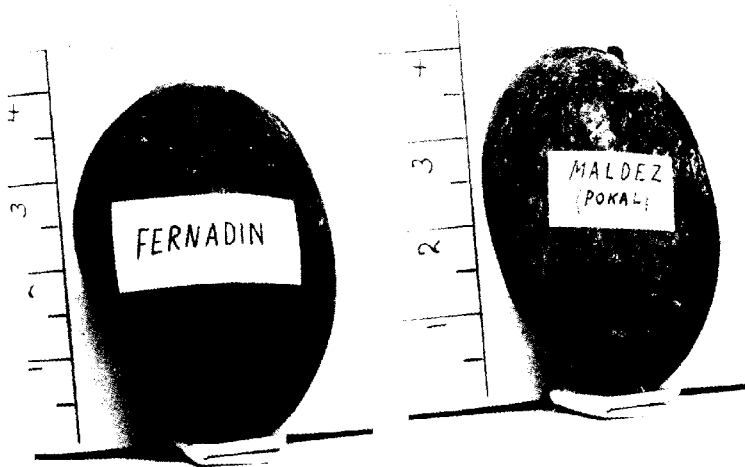


FIG. 5.

In Thorla-Goa a planter, who has a considerable area under mango, told me that in the year 1911, three trees fetched him in all sixty rupees, each tree bearing from two to three thousand fruits, whereas the following year, the same trees were sold for Rs. 15, each bearing not more than five to eight hundred fruits.

Suggestions :—Regarding this, I have got very little to say, as the trees bear profusely notwithstanding their struggle against all the diseases that have crept in. But it is true that very little attention is bestowed upon manuring and watering of the plants. Pruning of decaying and dead branches and removal of *Loranthus* which is becoming a more serious pest every day, is not done at all. If these things are looked to and if systematic pruning and manuring of the trees is adopted, the trees would bear immensely and would greatly benefit the people, who are already getting good returns from the fruits.

GROUND-NUT IN GUJERAT.

BY

C. V. SANE, B. Ag.,

Superintendent, Model Farm, Baroda.

It has been generally supposed that ground-nut cannot be grown as a profitable crop in Gujerat. The knowledge of the early exotic ground-nuts, Spanish pea-nut and small Japanese, and the results obtained therefrom have, however, considerably altered this view and now ground-nut is one of the principal crops, recommended by the Agricultural Department to the cultivator. These varieties were first tried on the Government Farm at Surat, and naturally, therefore, the extension of the crop has taken place in S. Gujerat, of which Surat forms the centre. It must not be imagined, however, that the crop is extending by leaps and bounds; but that it is continuously on the increase and gaining ground with the cultivators, can be easily seen by the increasing amount of seed distributed. The chief limitations to its spread are—

- (1) Its liability to damage from crows and jackals, and to theft.
- (2) The high cost of its cultivation.
- (3) Scarcity of labour at the time of harvest.

In the Deccan, in the Satara District, where ground-nut is extensively cultivated, this last difficulty is not so much felt in the case of the early varieties; for, being cultivated only on uplands, they mature at a time when labour is not particularly scanty. In the case of harvesting Pondicherry ground-nut, however, this difficulty does occur but does not form a complete bar to its cultivation, because it could be harvested later on by working

a heavy four-bullock harrow. Here, however, from this time onwards there is a continuous demand for labour in cutting grass, weeding, harvesting rice, etc., by the end of which time, if the crop be left unpicked, the soil gets too hard for working. It thus becomes necessary to harvest the crop when the soil is just suitable for easy uprooting.

The first difficulty is a real one, but as the crop becomes more general, losses from these sources will be considerably minimised; and the crop itself is sufficiently paying and valuable to allow for careful watching. But the tendency now seems to be in a different, but well-known direction, *i.e.*, towards a mixed crop. *Urid* (black gram) is a very favourite mixture on this side both with *Jowar* and in some cases also with cotton. It is an easy step for ground-nut to take the place of *Urid*. Cotton being a crop of a longer duration than *Jowar* and of deep feeding habit, a mixed crop of cotton and ground-nut in different rows, adjusted to leave sufficient space for the cotton to spread after uprooting the ground-nut is likely to give the best results.

Recently the same crop has been tried on a considerable scale in the light *Gorat* soil skirting the river Tapti and the crop appeared so luxuriant and vigorous that the cultivation may tend to become a permanent one in such soils. The varieties most in request are naturally the small Japanese and the Spanish pea-nuts, though here and there demands for big Japanese and other late varieties are also made. It is very difficult to decide as to which is superior between the small Japanese and the Spanish pea-nuts. The general impression is that the small Japanese yields better, but it does not find a ready sale for consumption owing to its uninviting appearance and oily taste. The Spanish pea-nut, on the other hand, is a finely coloured, attractive nut, but gives less outturn. The earliness of these types naturally enables them to make a successful stand against a comparatively dry season, but it has been observed this year that there was no other crop that was so little affected as ground-nut by the abnormally wet season and that made so successful a stand

against it. This adds one more argument in favour of its cultivation.

But while such is the state of affairs in S. Gujerat, in N. Gujerat ground-nut cultivation is practically unknown, owing to a variety of causes, the principal of which is fear of white-ants. As in S. Gujerat, ground-nut also displays here the characteristic of making a good stand against both dry and wet seasons, while as regards white-ants, looking to the outturns of both last and this year, given below, it will appear that the loss on this account is considerably overrated.

I.

VARIETY.	Rainfall in 1911-12 14.48 inches.	Rainfall in 1912-13 40.56 inches.	
	Nuts.	Nuts.	Creepers.
	lbs.	lbs.	lbs.
Tamboo	2,000	2,656	6,080
Senegal	1,073	1,890	5,920
Small Japanese	1,453	2,336	3,800
Spanish pea-nut... ..	2,300	2,032	4,200

While thus, on the one hand, there is no appreciable damage from white-ants, it has also the rare fortune of being safe from the attack of *Katras* (hairy caterpillars)—a great scourge of most other crops.

PROFIT.

It must be confessed that the cost of cultivation is high, the two costly items being harvesting and seed charges. But to compensate for this, the net profits are also proportionately big, as will be seen from the table given below showing this year's figures of outturn, value and cost.

II.

VARIETY.	OUTTURN PER ACRE.		Value of outturn.*	Cost of cultivation.	Profit.
	Nuts.	Creepers green.			
<i>Late.</i>	lbs.	lbs.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Tamboos ...	2,656	6,680	175 8 0	113 0 0	62 8 0
Senegal ...	1,860	5,920	125 8 0	113 0 0	12 8 0
<i>Early.</i>					
Small Japanese ...	2,336	3,800	151 15 0	80 15 0	71 0 0
Spanish peanut ...	2,032	4,200	133 9 0	80 15 0	52 10 0

* The nuts were sold at Rs. 2-8-0 per maund of 40 lbs. and the creepers at one anna per 40 lbs.

CULTIVATION.

The main items of cultivation charges are roughly given below from this year's cultivation sheet of a varietal test.

III.

OPERATION.	Cost in early types per acre.	Cost in late ones.
	Rs. A. P.	Rs. A. P.
1. Preliminary tillage ...	7 12 0	7 12 0
2. Manure, 20 cartloads ...	19 8 0	19 8 0
3. Cost of seed and sowing 80 lbs. of kernels. ...	13 3 0	13 3 0
4. Weeding & interculture ...	9 5 0	9 5 0
5. Harvesting ...	31 3 0	63 4 0
Total ...	80 15 0	113 0 0

Cultivation of the crop begins with a ploughing with a B. T. 2 plough after the previous crop is removed, between December and March; manure is applied at the rate of 20 cartloads per acre in May. After the rains begin, the manure is mixed in with a plough and seed sown with a three coultered drill by about the last week of June. About ten days later, a hand weeding and hoeing is given and blanks are filled in. Another interculture and weeding is given a fortnight later. By the beginning of August the crop is once more weeded and intercultivated and by the middle of August a country plough is

worked between the rows to keep the soil loose. With a field in good condition, this is the last cultural operation, but one more weeding may sometimes be found necessary in September. In normal years, the early types ripen four months after planting. Owing to wetness of the season, however, this year they were harvested by the end of November. The late varieties were harvested a fortnight later, but showed no sign of want of water and were given none. These had to be hand-dug, an enormously costly operation, as will be seen from the above table.

A peculiar feature that is common to both early and late varieties is that the creepers do not dry and die down as is always the case in the Deccan. Not only this but new pods were seen forming even as late as November, so that at whatever stage we harvest the crop from October to December, some pods will remain immature. A peculiarity of the late types was that the pods were mostly formed and found within the depth of four inches. It may be due to the fact that these were not watered and so the soil, setting hard below, did not allow easy penetration for the elongated peduncle.

LINE OF INVESTIGATION.

On referring to the cost of cultivation table, it will be seen that leaving manure out of consideration, the other two costly items are sowing and harvesting charges. Even the manure cannot wholly be put to the charges of ground-nut alone. Below are given for comparison results from an unmanured field which shew that the crop was a good one under such conditions.

IV.

VARIETY.	PRODUCE.		Value of outturn.	Cost of cul- tivation.	Profit.
	Nuts.	Creep- ers.			
	lbs.	lbs.	Rs. A. P.	Rs. A. P.	Rs. A. P.
Spanish pea-nut	2,546	4,733	166 8 0	54 3 0	112 5 0
Small Japanese	1,826	4,113	114 4 0	54 3 0	60 1 0

The cost of manuring, therefore, must be distributed over say three years, which will then increase the profits by another Rs. 10 to Rs. 12 in the case of statement II. The best way perhaps of applying this manure would be to give it to cotton with ground-nut and *Bajri* taken in successive years, making a complete three years' rotation of cotton, ground-nut and *Bajri*: for there is no doubt that good crops of cotton could be grown in this region.

The cost of seed could be reduced by experimentally testing how far the seed rate could be reduced with the best economic results. In the meanwhile, reserving one's own seed may considerably lighten the burden. But what is really burdensome is the cost of harvesting, which is so heavy in late varieties as to be almost prohibitive. It is probable that irrigation may conduce to reducing this somewhat, but whether it would bring it down to some reasonable amount can only be decided by experiments. Thus anything that will lighten this heavy burden will pave the way for popularizing the crop. Reference has already been made above to the fact that at whatever stage between October and December the crop may be harvested, a number of pods will always remain immature. The later they are harvested the heavier the charges become, but some more outturn may be realized. Early harvesting at a time when the uprooting will bring up most of the pods before the soil is completely dry, will reduce the cost, but to some extent the outturn as well. The best time, therefore, for harvesting the crop so as to leave the largest net profits can only be determined by fortnightly trials of harvests from October to December. Land commanded by irrigation can be harvested if a watering is given so as just to moisten the soil.

CONCLUSION.

It will be seen from the above that there are no obstacles—physical, climatic, seasonal, or agronomical to the cultivation of this crop, at least in parts where the conditions of soil and season like those of Baroda prevail. On the other hand, the crop has

yielded an outturn which will leave as good a profit as tobacco, the money-making crop of this tract; white-ants do not appreciably damage the crop, while it enjoys freedom from the attack of *Katras*. In addition, it opens up a way for systematic rotation. What really matters, and more so in the initial stages when the fields will be few and far between is the molestation of the crop by birds, beasts and thieves. It is to be hoped, however, that as the crop yields large profits, pains will be taken to watch and protect it and, as the area will extend, these depredations will be less serious. How the cultivators take it, the future will show.

NATURAL ROOT-GRAFTING.

BY

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Imperial Economic Botanist.

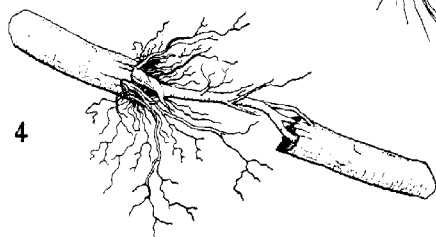
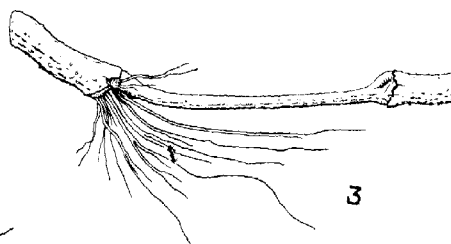
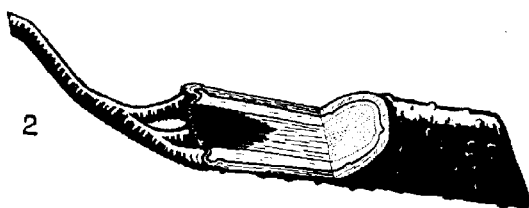
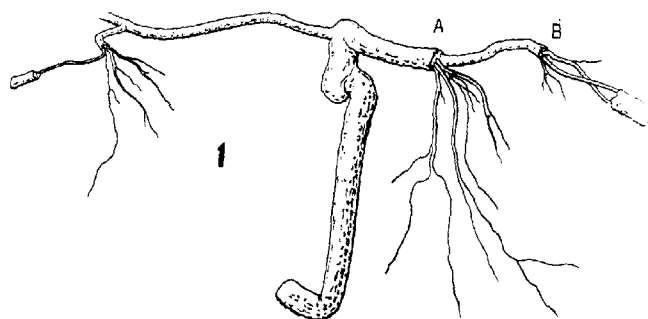
THE harmful effect of trees on crops in India is well known particularly in *barani* or dry crop areas where soil moisture is a limiting factor in production. Whenever a field is surrounded by trees, the soil moisture in the *rabi* season is notably deficient on the boundaries near the trees and only gradually increases towards the centre of the field. The effect on a crop is very soon evident. When the defect in moisture is very great, germination is affected round the edges of the field and, even if a few weak seedlings are produced, these wither away as the season progresses. If the soil moisture is more abundant at sowing time, germination may be even over the whole of the field, but the early promise is seldom or never maintained. Sooner or later the crop on the land affected by the tree-roots falls behind the rest, and commonly shows a yellowish, starved appearance. Such areas always exhibit all the phenomena of premature ripening. These are the obvious effects which result from the presence of trees near cultivated land. There can be no doubt, however, that the total effect is much greater than the observed effect and that larger areas are in reality affected. In all probability there is a gradual transition between the badly affected areas and the normal crop, and a good deal of damage occurs which is not evident to the eye, but which can only be detected by accurate weighments of the produce on fields in which other disturbing factors have been removed. Where solitary trees occur in cultivated fields, similar results are

observed. The trees are generally surrounded by a zone of weak stunted plants, the effect varying with the season and with the kind of tree. The cultivators in the plains of India are fully alive to these facts, and clearly recognise the harmful effects of trees on their crops and are positive that some trees do more damage than others.*

In the laying out of the botanical area at Pusa, the harmful effect of trees on the cultivated land in the neighbourhood had to be considered, and great efforts were made to reduce this disturbing factor to a minimum. A large number of trees and bamboo clumps were removed altogether, while the influence of the few remaining was checked by cutting deep trenches every year between the trees and the cultivated area. In the case of bamboos and several trees this has been very effective, but in other instances cutting the roots has not led to any permanent results. In addition, an increased tendency of root encroachment has been noted since the present system of cultivation has been adopted, particularly in the case of the banyan and pipal. The distance to which the roots of the pipal extend is very great. At Pusa large roots were discovered under thin patches of crop at the following distances from the parent tree—183, 194, 206 and 217 feet.

Root-cutting was followed by negative results in the case of three trees—pipal, banyan and teak. In every case, a year after the roots had been cut, it was observed that the effect on the plots could still be detected. On carefully opening the old trenches in 1912, twelve months after the last root cutting, it was found in the case of the pipal and banyan that the severed roots had become connected and that natural repair had taken

* There is no doubt some trees appear to do much more harm to crops than others, at least the effect is more evident in certain cases. At Pusa, in addition to bamboos, the following trees damage the crops in their neighbourhood to a very marked extent—teak (*Tectona grandis* Linn.), tamarind (*Tamarindus Indica* Linn.), pipal (*Ficus religiosa* Linn.), and banyan (*Ficus Bengalensis* Linn.). The subject of the effect of different trees on cultivation is an important one in India and needs investigation. The results of such studies should be considered in all future arboricultural schemes. If possible, trees should be selected for avenues in the country which, while desirable as roadside trees, do the least damage to the cultivators' crops.



place. This was accomplished by means of one of the numerous new roots, produced at the cut end of the root attached to the tree, growing across to the severed portion through from two to three feet of soil. The cut off portion of the root behaved as a cutting and did not die before union took place. Repair was in all cases effected by a process of natural grafting between the new roots and the completely cut off portions. This took place by the growth of the connecting root under the cortex of the severed portion when natural grafting occurred followed by a rapid thickening of the connection. The distances between the cut surface of the original roots varied from 24 to 30 inches, while the diameter of the new connecting part varied from 0.8 to 1.1 inches. This growth in thickness must have taken place in less than twelve months as some time must have elapsed after cutting before the connection occurred.

The details of this natural root-grafting are shown in Plate XXVIII. Figures 1, 2 & 3 refer to the banyan, while Figures 4 & 5 relate to the pipal tree. In Fig. 1 a portion of the banyan root system is shown. A large root is figured which suddenly bends vertically upwards and then divides into two horizontal portions both of which were cut when the trench of 1911 was made. At A the connection made in 1910 is shown, while at B the junction of 1911 can be seen. This case is interesting in view of the statements made by the cultivators that in both the banyan and pipal the roots come to the surface to feed at great distances from the tree and that the cutting of trenches six feet deep or so will not intercept all the roots. This is certainly the case in the pipal where some roots were not met with till a depth of nearly twelve feet was reached, while in the banyan, roots have been found as low as ten feet in trenches dug well beyond the spread of the branches. A section through the point of union in the case of the banyan is shown in Fig. 2. The decay at the cut end of the severed portion was very small and hardly exceeded two inches. The old wood is seen surrounded by a new growth of active wood which probably formed after natural grafting was completed. In Fig. 3 a case of complete repair is shown and

the cut surface of the severed end has been covered in completely by new growth. The corresponding details with regard to the pipal are shown in Figs. 4 & 5. The method of union in this case is the same as before, but more decay took place at the cut end, and the grafting process does not appear to be quite so rapid as in the case of the banyan.

Natural grafting was not observed in the case of the sissoo tree (*Dalbergia sissoo* Roxb.). Here the severed portions died and no case of natural union was found. In the case of the teak no natural grafting was seen, but in this tree the cutting of the roots was not followed by any permanent results in so far as the neighbouring crops were concerned. This tree appears to dry the soil in its neighbourhood much more than other trees, and it may be that the water content of the land is being continually lowered in the neighbourhood of the tree even beyond the range of the roots. In any case the digging of trenches six feet or more in depth between a teak tree and cultivated land has no permanent result in arresting the damage done.

From the point of view of the experiment station worker in India the subject of the effect of the growth of trees in the neighbourhood of cultivated land is an important one. This is particularly the case in the growth of *rabi* crops in the dry crop areas where soil moisture is a limiting factor in production. Certain trees appear to do more damage to crops than others—at any rate, the effect is more obvious in some cases than in others. All trees, however, are probably harmful as their presence must result in greater competition for the available supply of soil moisture. Besides the visible effect of the roots on the crop it is likely that a wider area is influenced by the roots and that the damage is much greater than would appear at first sight. Again when trees occur between cultivated and uncultivated land it is probable that root development is stimulated on the side towards the crops as here the supply of moisture and food material is likely to be greater than in areas under grass. In variety trials and field experiments where the aim of the experimenter is to reduce errors to a minimum, there can be no

doubt that the presence of trees introduces a disturbing factor. Until we know with precision the distribution of the root system of different trees and the effect on neighbouring land of the local reduction in soil moisture near trees like the teak it is impossible to estimate the amount of damage done. The ideal experiment station is one without any trees at all, but this is difficult to obtain on account of the prejudices often aroused by the cutting down of avenues and shade trees. Until the whole subject is better understood in India and the methods of conducting field trials are examined in detail, all that seems possible is to free a portion of an experiment station from trees altogether and to restrict critical field trials to this area. This naturally reduces the amount of work possible and interferes with the utility of the station.

IN DEFENCE OF THOSE AGRICULTURAL
SCIENTISTS WHO ARE NO LESS AGRI-
CULTURAL THAN SCIENTIFIC.
A REVIEW.

BY

A. C. DOBBS, B.A.,

Asst. to the Agri. Adviser to the Govt of India.

THERE has recently fallen into the writer's hands a copy of "The Cotton Plant in Egypt—*Studies in Physiology and Genetics*" by W. Lawrence Balls, M.A., Botanist to the Department of Agriculture, Egyptian Government (Macmillan's Science Monographs).

This book which, as we learn from the preface, was written primarily "for those few Economic Botanists who are more botanical than economic," abstracts "the results of a series of researches made upon cotton plants in Egypt, . . . connected by the desire to know all that could be learnt about the plant itself;" and if the lay reader is predisposed by this introduction to look somewhat critically for any other motive connecting these researches, and hardly feels disappointed at his inability to find any, it may perhaps be ascribed to his sense of irritation at the invidious distinction between pure and economic botany, implied by the author.

Possibly no reader of the book, certainly not the layman, will question its thoroughly "scientific" character. It is a mass of figures, diagrams and curves in which are presented quantitatively in what is, from the mathematical point of view, the most concise and intelligible form, the variations in the environment of the cotton plant in Egypt and in its physiological functions:

the correlation between the two being worked out in a large number of cases after the methods popularised by Galton and Karl Pearson.

And, without the technical knowledge to enable him to form an estimate of the skill and judgment with which these methods have been used, the reader is free to admire the ingenuity and industry displayed by the author in their application. Indeed, one puts down the book with a feeling that one has seen all the most recent machinery of science called in, to collect data and construct a series of mathematical formulæ which would probably, if one ever happened to be in circumstances in which they would be of any use, prove quite reliable.

But at the same time one feels that by the use of a little commonsense, a little intuition, by taking even a slightly broader view, one could probably always, and with advantage, avoid being reduced to the point of having to use them. Who, for instance, that has gardened in a hot climate, does not know, by the intuition derived from many little unrecorded observations, the stunting effect of the afternoon sun in dry weather, shown in extreme cases by the flagging of leaves and remedied by judicious pruning or shading; or again the unhealthy appearance of plants that are suffering from water-logging either owing to bad drainage or heavy and prolonged rain: and why—why is it necessary to measure and record, as the author has done, the exact value of the factors concerned in any particular case?

If it is really, as the preface implies, only the desire to know *all* that can be learnt about the plant itself, the book can only be regarded as a contribution towards the accumulation of what Professor Soddy* calls the “mere knowledge” . . . “however complete and accurate” which will go to “deaden rather than develop the intellects” of future students of Physiology and Genetics.

But if we assume that these investigations are not blind alleys, that the author had in view some scientific object for

* Matter and Energy. Williams and Norgate, 1912.

the ultimate attainment of which these—may one say—*sordid* quantitative investigations are essential; the fact remains that the large amount of work here recorded does not appear to be of any immediate economic importance.

Moreover, it may be suggested that even from the scientific point of view, the expenditure of time by an official of an Agricultural Department on such work is a mistake.

If we cannot quite logically say that science was made for man and not man for science, it is at least questionable whether the soundest view to take of the work of a scientist paid in any interests, is not that he should be guided primarily by the economic requirements of the interests in which he is paid. We know that the rendering to Cæsar of the things which are Cæsar's is not incompatible with the highest of ideals.

No one will deny that apparently unimportant scientific investigations have often led to most important practical results, but it is legitimate to assume that, other things being equal, such results would have been more systematically of economic importance if the importance of economics had been kept more systematically in view in directing the investigations.

It is questionable whether the field of so called "pure" science should not be left to those whose circumstances permit them a perfectly free selection of phenomena to investigate.

For indeed the purity of a science is only the purity of motive, choice, and vision of the investigator, and a careful estimation of the relative importance of the different aspects of the phenomena investigated, from the point of view of the interests in which the investigations are undertaken, is an antecedent condition of the purity of the scientific work of a paid investigator.

The purity of the science of Astronomy arises, not from the fact that its economic application is for the most part indirect, but because, this being so, its relative simplicity and attractiveness for the human mind have resulted in its being studied for its own sake apart from any economic considerations; *per contra* it can only add to the purity of an economic investigation if it is

based on a primary choice of phenomena of economic importance to investigate.

From this point of view such an investigation of the cotton plant in Egypt should begin at the diametrically opposite pole from that of "studies in Physiology and Genetics." The agricultural conditions should first be studied, from the agricultural standpoint, with a view to the acquisition of that intuitive sympathy with the plant, that comes from even a comparatively short, if detailed, personal acquaintance with the scientific application of the ordinary agricultural operations of draining, cultivation, and irrigation—an intuition which integrates in itself the results of numberless observations of the continuous interplay of physiological phenomena, in a way that the merely mathematical investigation of isolated factors can never emulate: just as the perfectly automatic nature of the control of the beating of the heart, sums up phylogenetically and better than could be contrived by any conceivable proficiency in medical science, the practical experience of æons in the regulation of blood circulation.

The conditions for the production of the optimum agricultural results having thus been brought within the control of the investigator, the isolation, by breeding and selection, of those characters of the plant that are directly or indirectly of positive economic importance under local conditions becomes a comparatively straightforward, if massive, piece of work—to be followed by the synthesis of such useful characters as are not incompatible.

It is not implied that the work is easy, or that there is not ample room for the exercise of scientific accuracy in the preliminary observations on the growth, habit, pollination, etc., of the plant, but such observations are essentially qualitative and do not necessitate exact quantitative estimations of the physiological relations between plant and environment, any more than due attention to the points of—shall we say—liveliness and 'skin' of a milch cow, necessitate a measurement of the length of her paces or of the composition, diameter and number per square inch of hairs on her flanks. It is only some of the more important

economic characters of the plant that require exact quantitative comparison, and this can be made relatively simple.

It is a matter for regret that the author should have added one more to the list of scientific books that give cause for the enemy to blaspheme. May one express a hope that his obviously great gifts of intellect and energy may be turned from pedantic devotion to a merely mathematical ideal into channels of more practical, and therefore from an economic point of view more pure, scientific interest.

NOTES.

THERE have recently been conducted at Coimbatore some feeding tests to ascertain the benefit to be obtained by chaffing fodder (sorghum straw) as against the common system of cutting or breaking it into lengths of 12 inches to 18 inches. The method adopted was to give the animals their normal concentrated ration of 1½lbs. cotton seed and 1½lbs. of groundnut cake, along with a minimum ration of chaff. This was then changed to chopped fodder, which was gradually reduced until the animals just showed signs of losing weight, when the same quantity of chaffed straw was substituted. The test was made on six animals for the first two months, and four animals for the last six weeks.

The experiment has been a failure, probably from two causes. Firstly, it was not possible to arrange uniform work for the animals during successive periods of feeding, as at the start of the experiment they were engaged in the heavy work of lifting water, while at the end they were doing light carting work. Secondly, all the animals showed extraordinary daily fluctuations in their weights, amounting at times to more than 10 per cent.

The writer would be glad if any of the readers of this Journal can corroborate these difficulties from their own experience or throw any light on the variation which may be expected in *working* animals; most feeding tests are of course concerned with fattening animals. In conclusion it may be said that the experiment was conducted as accurately as possible in the condi-

tions obtaining in a well-equipped provincial station.—(R. CECIL WOOD).

A paper in the *Journal of Agricultural Science*, Vol. III, Part 4, by Professor Wood and Mr. Stratton, of Cambridge, gives the probable error in cattle-feeding experiments as 14% of the live weight increase for a single animal. Considering the additional difficulty of measuring the amount of work done by working animals, it is probable that a number of animals far greater than those mentioned in the above note, would be needed to render the results at all significant.—EDITOR.

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THE following extract from a summary in *Nature* of the discussion on animal nutrition at the last meeting of the British Association, may serve as a warning to any who may tend to place too much reliance on chemical analysis of food-stuffs as a guide in the feeding of livestock. Incidentally it also affords testimony in favour of Bombay cotton cake as a food-stuff :—

“ For the past ten years an important series of sheep and cattle feeding experiments has been carried out by Mr. Bruce, and the results were very ably summarised by Mr. Watson. A remarkable feature was the pre-eminent position of linseed cake as a food, animals fed on this always making greater progress than those on other substances. Better results were also obtained with Bombay cotton cake than with Egyptian cotton cake, in spite of their apparent identity on chemical analysis. A mixture of wheat, cotton-seed and cotton cake made up to give the same analysis as linseed cake proved economically a failure. The conclusion is drawn that our present methods of valuing feeding stuffs do not afford particularly useful information. Prof. F. G. Hopkins dealt with the discrepancy. Until recently physiologists had been content to express diet in terms of energy and protein minimum, neglecting other factors. It is now known that these other factors do matter, and that one cannot group together all the constituents either in terms of a starch equivalent or of any other unit. There are other constituents just as important as carbohydrate, protein, or fat, and if these are

removed, the diet may lose much of its value or even predispose to disease. Dr. Fünk gave an actual illustration in the work that he has been doing at the Lister Institute on the isolation of the so-called vitamine from rice polishings."

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THE MANGUM SYSTEM OF FIELD TERRACING.—This system is described in Circular No. 94 Bureau of Plant Industry of the U. S. A. It differs from other systems of terracing in having a broad terrace bank of about 15 feet in place of the usual narrow strip of grass. The bank comes under cultivation with the rest of the field, and it is claimed that the system saves a great waste of land and of labour in cultivating and weeding and has the effect of keeping down weeds and diminishing the damage done by insects.

A convenient way of laying out the fields is described in the circular and also a cheap form of level for laying off the terrace lines. The terrace banks are built up by repeated ploughings round the terrace lines as crowns. A gradient of $\frac{1}{2}$ inch in 14 feet is considered the most suitable for the terrace lines which are usually laid off at intervals of 6 feet of fall in the slope of the land.

The banks once made require little attention. In fields of ordinary slope the terrace may be disregarded, except that all dead furrows should be filled up in ploughing across. On extremely steep land however the ploughing is done in contours.—(S. MILLIGAN.)

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NITROLIM.—Not many years ago some eminent scientists predicted a nitrogen famine and the rapid exhaustion of the world's supply of available nitrogen was a source of great concern. But it was not long until it was discovered that atmospheric nitrogen could be fixed by means of the electric arc, and thus an inexhaustible store-house was thrown open. Soon the methods for the fixation of atmospheric nitrogen were improved upon and cheapened until it became possible to produce it in large

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quantities to compete with nitrate of soda and sulphate of ammonia. Norway leads in the manufacture of this new fertilizer known as cyanamide or nitrolim, and if the plans of the Norwegian Hydro-electric Nitrogen Co. mature by the close of 1916, waterfalls in Norway to the enormous total of 540,045 horse-power will be utilized in the manufacture of nitrolim.—(*Philippine Agricultural Review*, January, 1913.)

It has for some time been evident that the supply of combined nitrogen is only a question of the energy available for effecting the necessary combinations. But that the amount of such energy required will always be considerable is shewn by the power of nitrogenous explosives.

The sources of power are being rapidly appropriated as the above extract shows, and it is only a question of time when its use for increasing the production of food for the general mass of humanity will begin to compete with its use for such special purposes as, *e.g.*, motoring.

From this point of view, may not the disproportionate rise of food-prices in India be regarded as the result of a similar competition between the relatively specialised activities of the West and the massed populations of the East, now brought into closer contact by improved communications?

When an industrialised Asia begins to import food, and famine ceases to restrict the growth of her populations, Europe will be faced with a new situation.—(A. C. DOBBS.)

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JOURNAL OF THE MADRAS AGRICULTURAL STUDENTS' UNION.—The past students of the old Saidapet College and the past and present students of the Agricultural College, Coimbatore, have formed a Union under the name of "Madrass Agricultural Students' Union." Its principal objects are to foster a spirit of brotherhood among the students and to exchange ideas. It also serves as a bureau for procuring employment as far as possible for its members. It is two years since it was organised and in this short period it has been able to enrol 138 members.

When the proposal for the formation of this Union was mooted, some of the old students suggested that its objects would be best achieved by the issue of a periodical publication. In response to this suggestion the Union has started a Quarterly Journal called "The Journal of the Madras Agricultural Students' Union," the first number of which is to hand. It contains useful information regarding the College and the Agricultural Department, and simple articles on agricultural subjects.

To afford its members an opportunity of meeting and exchanging views, the Union holds a gathering every year in July. Two such gatherings have been held and have been attended by officers of the Agricultural Department and by rich zemindars. The principal feature of this annual gathering is the holding of a Conference on the day of the gathering at which papers on agricultural subjects are read. At the Conference held in 1912, several papers were read of which those by Dr. C. A. Barber on "Sugarcane Seedlings in India," and by R. B. J. Dharmaranga Raju on a "Suggestion for accelerating the introduction of Agricultural Improvements in the Madras Presidency" have been published in the first number of the Journal of the Union. The former has since been published in the October (1912) number of this Journal.

REVIEWS.

“SOIL, ITS TREATMENT AND AGRICULTURAL IMPLEMENTS.” A
PAMPHLET IN MARATHI BY RAO SAHEB G. K. KELKAR, ASSISTANT
PROFESSOR OF AGRICULTURE. AGRICULTURAL COLLEGE, POONA.
Price As. 8.

THE aim of this Vernacular publication is to place before the cultivating classes, especially those of the Deccan, all the available information on the subject of improved agricultural implements which have been successfully tried on the Farms of the Bombay Presidency. After describing briefly the conditions of soil and climate obtainable in the Deccan and the improved methods which should be adopted for the preparation of the various classes of soil in order to ensure the largest possible outturn, the author gives an illustrated description of the various implements necessary to bring about the desired improvements. The advantages of iron ploughs, harrows, etc., in reducing the soil to a fine tilth—a condition which is so necessary for the conservation of soil moisture in tracts like the Deccan where the rainfall varies from 15 to 30 inches—are fully discussed, and every other information about these appliances (such as cost, methods of using, etc.) is given. Besides tillage implements, the author also supplies similar information about seed drills, threshers, winnowers, chain pumps, etc., the advantages of which have first been ascertained on the Government Farms. In short, the pamphlet contains all about useful agricultural implements tried on the Bombay Farms and is likely to serve the purpose for which it is written—namely, to spread the knowledge of such appliances.

A similar publication in English issued by the Mysore Department of Agriculture has also come to hand.--(S. D. M.)

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NAKHLISTAN, PART I. BY ABDUL KADAR KHAN, PRINTED AT THE UNION STEAM PRESS, LAHORE. Price As. 8.

THIS book has been written in Urdu by a resident of Multan District, who claims that he has over 18,000 date-plants in his own garden, but the reader will be disappointed to find that very little has been written from personal experience.

The bulk of the subject-matter has been taken from different English papers, and badly translated. Especially in dealing with scientific points the author has himself been confused; for instance, under pollination he writes on page 66: "In the matter of sex the date-palm is quite different from other plants. In other plants when flowers are borne one is male and the other is female, etc., etc." The general language of the paper also requires revision.

There are 8 chapters in the book as follows:—

- (1) Soil and climate.
- (2) Preparation of land and manure.
- (3) Method of planting.
- (4) Time of selection from the nursery.
- (5) Arrangement of plants.
- (6) Pollination and pruning.
- (7) Nourishment, watching and irrigation.
- (8) Diseases.

Every chapter contains many useful points, though in some cases the information given is misleading.

At the end the author gives a statement of the different varieties of date-palm with the names of countries in which they are grown, and as is often the case he forgets his own country and gives no names of any varieties found at Multan and in the neighbouring districts.—(A. R. K.)

THE Bulletin of Agricultural Intelligence and Plant Diseases for December, 1912, issued by the International Institute of Agriculture, contains under the heading of "Edaphism," an abstract of papers by G. Gola of the Botanical Institute of the University of Turin on the relations between the plant and the soil, with particular reference to the chemical and physical constitution of the soil-water; and gives, in a very condensed and dogmatic form, the conclusions drawn by the author from his researches. Many of these are of interest from the point of view of Indian agriculture, and the following extract is given as a specimen.

"The *drying up of the soil* even at ordinary temperatures causes a very considerable increase in the amount of soluble substances before the advent of rain; a light rain in such a case produces a highly concentrated medium around the roots of plants, whilst continued rain causes a much greater impoverishment of the soil than if the soil were to keep fresh and slightly moist. The influence of drought on the increase of soluble substances is least in soils very rich in neutral salts (sodium chloride, magnesium sulphate), and much greater in those containing alkaline substances in a state of complex combination. The increase of salinity of the dried soil is due in the first place to the dehydration of many compounds of the soil itself, and also to the ascent by capillarity of the saline solutions existing in the lower layers of the soil and which concentrate at the surface, causing the formation of crusts and even of efflorescences. This is important because it allows the return to the surface of substances which had been dragged by the rain down to the deep layers of the soil. In this mobility of the substances contained in the liquids of the soil, the most important part is played by crystalloids, the least by colloids. Lastly, the superficial drying and consequent ascent by capillarity of saline solutions is much more marked in averagely porous soils, and its effects being more felt in regions subject to long alternating periods of drought and of rain, it may cause very great oscillations in the concentration of the liquids surrounding the roots."

Other interesting abstracts in this number relate to the "Effects of Continuous Cropping and Rotation on the Bacterial Flora of the soil" and to the "Lateritization of the soil under Arid Climates."

This useful monthly bulletin has now been issued regularly since November 1910 and the need of an index to facilitate reference is becoming urgent.—(A. C. D.)

**LIST OF AGRICULTURAL PUBLICATIONS IN
INDIA FROM 1ST AUGUST, 1912.
TO 31ST JANUARY, 1913.**

No.	Title.	Author.	Where published.
<i>General Agriculture.</i>			
1	The <i>Agricultural Journal of India</i> , Vol. VII, Part IV, and Vol. VIII, Part I. Price per part, Rs. 2; annual subscription, Rs. 6.	Issued from the Agricultural Research Institute & College, Pusa, Bihar.	Thacker, Spink & Co., Calcutta.
2	Report of the Agricultural Research Institute and College, Pusa (including the report of the Imperial Cotton Specialist), for 1911-12. Price 6 annas or 7d.	Director, Agricultural Research Institute, Pusa.	Government Printing, India, Calcutta.
3	Wheat Experiments on the Botanical Area, Cawnpore, and their bearing on wheat cultivation in the United Provinces. Bulletin No. 31 of the Agricultural Research Institute, Pusa. Price 3 annas or 4d.	H. Martin Leake, M.A., Economic Botanist to Government, United Provinces, and Ram Prasad, Assistant to the Economic Botanist.	Ditto.
4	Agricultural Statistics, Vol. I, from 1906-07 to 1910-11. Price Rs. 2-8 or 3s. 9d.	Director-General, Commercial Intelligence.	Ditto.
5	Oils and Fats of India, Agricultural Ledger No. 5 of 1911-12. Price 8 annas.	David Hooper, F.C.S., F.I.S.	Ditto.
6	<i>Quarterly Journal</i> , Vol. V, No. 4 for April, 1912. Price 6 annas.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Press, Calcutta.
7	Hints on the cultivation and curing of tobacco, leaflet No. 4 of 1912, of the Department of Agriculture, Bengal.	N. C. Chowdhury, Travelling Inspector.	Ditto.
8	Season and Crop Report of Bengal for 1911-12. Price 8 annas or 9d.	Issued by the Department of Agriculture, Bengal.	Bengal Secretariat Book Depot.
9	Annual Report of the Department of Agriculture, Bengal, for the year ending 30th June, 1912. Price 7 annas.	Ditto.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
<i>General Agriculture—contd.</i>			
10	Report on the administration of the Department of Agriculture, United Provinces, for the year ending 30th June, 1912. Price 8 annas or 9d.	Issued by the Department of Agriculture, United Provinces.	Government Press, United Provinces, Allahabad.
11	Report on the Aligarh Agricultural Station for the year ending 30th June, 1912	Ditto.	Ditto.
12	Report on the Partabgarh Agricultural Station for the year ending 30th June, 1912.	Ditto.	Ditto.
13	Report on the Cawnpore Agricultural Station for the year ending 30th June, 1912.	Ditto.	Ditto.
14	Season and Crop Report of the United Provinces of Agra and Oudh, for the year 1911-12. Price 8 annas or 9d.	Ditto.	Ditto.
15	Note on Manures in the Punjab	W. Roberts, B.Sc., Professor of Agriculture, Agricultural College, Lyallpore.	Ditto.
16	Report on the operations of the Department of Agriculture, Punjab, for the year ending 30th June, 1912. Price 10 annas or 1s.	Issued by the Department of Agriculture, Punjab.	Government Press, Lahore
17	Season and Crop Report of the Punjab for 1911-12.	Ditto.	Ditto.
18	Report of the Government Horticultural Gardens, Punjab, for 1911-12.	Ditto.	Ditto.
19	Summary of remarks on the Kharif Crop of the N.-W. F. P. for 1912. Price 5 annas or 5d.	Issued from Office of the Revenue Commissioner, North-West Frontier Province.	N.-W. F. Province Government Press, Peshawar.
20	Report on the Season and Crops of the North-West Frontier Province for 1911-12. Price 10 annas or 10d.	Ditto.	Ditto.
21	Annual Report of the Department of Agriculture, Bombay, for 1911-12. Price 12 annas or 1s. 2d.	Issued by the Department of Agriculture, Bombay Presidency.	Government Central Press, Bombay.
22	Season and Crop Report of the Bombay Presidency for 1911-12. Price 7 annas or 8d.	Ditto.	Ditto.
23	Annual Report on the Surat Agricultural Station for 1911-12. Price Re. 1-0-0 or 1s. 6d.	Ditto.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
<i>General Agriculture—contd.</i>			
24	Annual Report on the Dharwar Agricultural Station for 1911-12. Price Re. 1 or 1s. 6d.	Issued by the Department of Agriculture, Bombay Presidency.	Government Central Press, Bombay.
25	Annual Report on the Dhulia Agricultural Station for 1911-12. Price 12 annas or 1s. 2d.	Ditto.	Ditto.
26	Annual Report on the Nadiad Agricultural Station for 1911-12. Price 14 annas or 1s. 4d.	Ditto.	Ditto.
27	Annual Report on the Dohad Agricultural Station for 1911-12. Price 8 annas or 9d.	Ditto.	Ditto.
28	Annual Report on the Gokak Agricultural Station for 1911-12.	Ditto.	Ditto.
29	Annual Report on the Alibag Agricultural Station for 1911-12. Price 10 annas or 11d.	Ditto.	Ditto.
30	Annual Report on the Gadag Agricultural Station for 1911-12. Price 12 annas or 1s. 2d.	Ditto.	Ditto.
31	Annual Report on the Mirpurkhas Agricultural Station for 1911-12. Price 8 annas or 9d.	Ditto.	Ditto.
32	Annual Report on the Sukkur Agricultural Station for 1911-12. Price 4 annas or 5d.	Ditto.	Ditto.
33	Annual Report on the Manjri Agricultural Station for 1911-12. Price 3 annas or 3d.	Ditto.	Ditto.
34	Annual Report on the Kirkee Civil Dairy for 1911-12. Price 3 annas or 3d.	Ditto.	Ditto.
35	Annual Report on the Agricultural College Station for 1911-12. Price 5 annas or 6d.	Ditto.	Ditto.
36	Annual Report on the Ganeshkhind Botanical Garden for 1911-12. Price 4 annas or 5d.	Ditto.	Ditto.
37	Annual Report on the Experimental work of the Bassein Botanical and Agricultural Station. Price 3 annas or 3d.	Ditto.	Ditto.
	Method of improving the quality of Cotton Seed, Bulletin No. 53 of 1912 of the Department of Agriculture, Bombay. Price 7 annas or 8d.	G. D. Mehta, L.Ag., N.D.A., N.D.D., Supernumerary Agriculturist and V. G. Gokhale, L.Ag.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
<i>General Agriculture—contd.</i>			
39	Scientific Report of the Samalkota Agricultural Station for 1911-12.	Issued by the Department of Agriculture, Madras.	Government Press, Madras.
40	Scientific Report of the Nandyal Agricultural Station for 1911-12.	Ditto.	Ditto.
41	Scientific Report of the Hagari Agricultural Station for 1911-12.	Ditto.	Ditto.
42	Scientific Report of the Palur Agricultural Station for 1911-12.	Ditto.	Ditto.
43	Scientific Report of the Koilpatti Agricultural Station for 1911-12.	Ditto.	Ditto.
44	Scientific Report of the Taliparamba Agricultural Station for 1911-12.	Ditto.	Ditto.
45	Scientific Report of the Coimbatore Agricultural Station for 1911-12.	Ditto.	Ditto.
46	Annual Report of the Agricultural Department, Madras, for 1911-12.	Ditto.	Ditto.
47	What the Ryots have to say about the single seedling planting of paddy. Leaflet No. 1 of 1913 of the Department of Agriculture, Madras. (In English, Tamil, Telugu, Malayalam and Canarese.)	H. C. Sampson, B. Sc., F.H.A.S., F.B.S.E., Deputy Director of Agriculture, Madras.	Ditto.
48	Season and Crop Report of the Madras Presidency. Price 4 annas or 6d.	Issued by the Department of Agriculture, Madras.	Ditto.
49	Report on the working of the Department of Agriculture, Central Provinces and Berar, for the year 1911-12. Price Re. 1.	Issued by the Department of Agriculture, Central Provinces and Berar.	Central Provinces Secretariat Press, Nagpur.
50	Report on the Agricultural Stations in the Central Provinces and Berar for the year 1911-12. Price Re. 1.	Ditto.	Ditto.
51	Report on the Management of the Provincial and District Gardens, Central Provinces and Berar, for the year 1911-12. Price annas 4.	Ditto.	Ditto.
52	Season and Crop Report of the Central Provinces and Berar for the year 1911-12. Price 8 annas or 9d.	Ditto.	Ditto.

LIST OF AGRICULTURAL PUBLICATIONS.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
<i>General Agriculture—contd.</i>			
53	The Monthly Agricultural and Co-operative Gazette, August, 1912 to January 1913. Price 2 annas per copy.	Issued by the Department of Agriculture, Central Provinces & Berar.	Desh Sevak Press, Nagpur.
54	Annual Report of the Department of Agriculture, Bihar & Orissa, for 1911-12.	Issued by the Department of Agriculture, Bihar and Orissa.	Bihar and Orissa Printing Office, Ranchi.
55	Annual Report of the Bankipur Agricultural Station for 1911-12.	Ditto.	Ditto.
56	Annual Report of the Dumraon Agricultural Station for 1911-12.	Ditto.	Ditto.
57	Annual Report of the Cuttack Agricultural Station for 1911-12.	Ditto.	Ditto.
58	Monsoon Rainfall Table for Bihar and Orissa for 1912.	Ditto.	Ditto.
59	Report on the crop cutting experiments conducted during the quinquennium 1907-08 to 1911-12.	Ditto.	Ditto.
60	Season and Crop Report of Bihar and Orissa for 1911-12. Price 6 annas or 6d.	Ditto.	Ditto.
61	Annual Report of the Upper Shillong Agricultural Station for the year ending 30th June, 1912. Price 2 annas.	Issued by the Department of Agriculture, Assam.	Assam Secretariat Printing Office, Shillong.
62	Annual Report of the Jorhat Agricultural Experimental Station for the year ending 30th June, 1912. Price 2 annas.	Ditto.	Ditto.
63	Report of the Agricultural Department, Assam, for the year ending 30th June, 1912. Price 8 annas.	Ditto.	Ditto.
64	Note on Manures. Bulletin No. 23 of 1912 of the Department of Agriculture, Assam. Price 1 anna.	Ditto.	Ditto.
65	Report on the Season and Crops of Assam for 1911-12. Price 8 annas or 9d.	Ditto.	Ditto.
66	Report on the operations of the Department of Agriculture, Burma, for the year ending 30th June, 1912. Price 12 annas or 1s.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
<i>General Agriculture—concl'd.</i>			
67	Report on the Mandalay Agricultural Station for the year 1911-12.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
68	Season and Crop Report of Burma, for the year ending 30th June, 1912. Price 8 annas or 9d.	Ditto.	Ditto.
69	Dry Weather Cultivation of Burmese vegetables on paddy soils. Cultivators' leaflet No. 39 of the Department of Agriculture, Burma.	Ditto.	Ditto.
70	Winnowing Machines. Cultivators' leaflet No. 40 of the Department of Agriculture, Burma.	Ditto.	Ditto.
71	Chain pumps. Cultivators' leaflet No. 41 of the Department of Agriculture, Burma.	Ditto.	Ditto.
<i>Agricultural Chemistry.</i>			
72	The Composition of the Milk of some breeds of Indian Cows and Buffaloes and its variations. Part II.—Memoirs of the Department of Agriculture in India, Chemical Series, Vol. II, No. IV. Price, Re. 1-8.	A. A. Meggitt, B.Sc., F.C.S., Agricultural Chemist, Bengal; and H. H. Mann, D.Sc., Principal, Agricultural College, Poona.	Thacker, Spink & Co., Calcutta.
73	A Contribution to the Knowledge of the Black Cotton Soils of India. Memoirs of the Department of Agriculture in India, Chemical Series, Vol. II, No. 5. Price, Re. 1.	W. H. Harrison, M.Sc., Government Agricultural Chemist, Madras; and M. R. Ramaswamy Sivan, B.A., Chief Assistant to the Agricultural Chemist, Madras.	Ditto.
74	Report on the Analytical Survey of Sugarcane in the Gurdaspur District (not for sale).	J. H. Barnes, B.Sc., F.I.C., F.C.S., A.R.I.P.H.	
<i>Mycology.</i>			
75	The Morphology and Parasitism of <i>Rhizoctonia</i> . Memoirs of the Department of Agriculture in India, Botanical Series, Vol. IV, No. 6. Price, Rs. 2.	F. J. F. Shaw, B.Sc., A.R.C.S., F.I.S., Supernumerary Mycologist.	Thacker, Spink & Co., Calcutta.
76	Bud-rot of Palms in the Godavari and Kistna Districts. Leaflet No. IV of 1912, of the Department of Agriculture, Madras.	W. McRae, M.A., B.Sc., Govt. Mycologist, Madras.	Government Press, Madras
77	Anthraxnose (a disease of the cotton plant). Cultivators' leaflet No. 34 of the Department of Agriculture, Burma.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.

LIST OF AGRICULTURAL PUBLICATIONS.

LIST OF AGRICULTURAL PUBLICATIONS—*contd.*

No.	Title.	Author.	Where published.
<i>Botany.</i>			
78	The Inheritance of some characters in Wheat, I. Memoirs of the Department of Agriculture in India, Botanical Series, Vol. V, No. 1. Price, Re. 1.	A. Howard, M.A., A.R.C.S., F.L.S., Imperial Economic Botanist; and G. L. C. Howard, M.A., Personal Assistant to the Imperial Economic Botanist.	Thacker, Spink & Co., Calcutta.
<i>Entomology.</i>			
79	The Cultivation of Lac in the plains of India (<i>Tachardia lacca</i> , Kerr). Bulletin No. 28 of the Agricultural Research Institute, Pusa. Price, 8 annas or 9d.	C. S. Misra, B.A., First Assistant to the Imperial Entomologist.	Government Printing, India, Calcutta.
80	Directions for the Cultivation of Eri-silk. Bulletin No. 29 of the Agricultural Research Institute, Pusa. Price, 3 annas or 4d.	Issued from the Agricultural Research Institute, Pusa.	Ditto.
81	<i>Tetrignus (Acridina)</i> in the Agricultural Research Institute, Pusa, Bihar, with descriptions of new species. Memoirs of the Department of Agriculture, Entomological Series, Vol. IV, No. II. Price, Re. 1.	J. L. Hancock, F.E.S.	Thacker, Spink & Co., Calcutta.
82	The Big Brown Cricket (<i>Brachytrypes achatinus</i> , Stoll). Memoirs of the Department of Agriculture in India, Entomological Series, Vol. IV, No. III. Price, Re. 1.	C. C. Ghosh, B.A., Assistant to the Imperial Entomologist.	Ditto.
83	Life-Histories of Indian Insects (<i>Hymenoptera</i>). Memoirs of the Department of Agriculture in India, Entomological Series, Vol. IV, No. 4. Price, Rs. 2.	G. R. Dutt, B.A., Assistant to the Imperial Entomologist.	Ditto.
84	The Jute Semi-looper (<i>Ghara Poka</i>). Leaflet No. 3 of 1912 of the Department of Agriculture, Bengal.	P. C. Sen, Entomological Collector.	Bengal Secretariat Press, Calcutta.
<i>Agricultural Bacteriology.</i>			
85	Studies in the Bacteriological Analysis of Indian Soils, Vol. I, No. 1. Memoirs of the Department of Agriculture in India. Price, Rs. 2.8.	C. M. Hutchinson, B.A., Imperial Agricultural Bacteriologist.	Thacker, Spink & Co., Calcutta.

LIST OF AGRICULTURAL PUBLICATIONS—*conold.*

No.	Title.	Author.	Where published.
<i>Veterinary.</i>			
86	A Note on some interesting results following the internal administration of arsenic in canker and other diseases of the foot in horses. Bulletin No. 32 of the Agricultural Research Institute, Pusa. Price, 2 annas or 3d.	Major J. D. E. Holmes, M.A., D.Sc., M.R.C.V.S., Imperial Bacteriologist, Muktesar Laboratory.	Government Printing, India, Calcutta.
87	Report of the Research Work of the Imperial Bacteriological Laboratory, Muktesar, during 1910 and 1911. I. C. V. D. Memoirs, No. 3. Price, Rs. 7.	J. D. E. Holmes, M.A., D.Sc., M.R.C.V.S., Imperial Bacteriologist.	Thacker, Spink & Co., Calcutta.
88	Annual Report of the Imperial Bacteriologist for the year 1911-12. Price, annas 3 & 4d.	Issued by the Agricultural Adviser to the Government of India.	Superintendent, Government Printing, India, Calcutta.
89	Salvarsan in the treatment of Surra in Horses, Dogs and Rabbits. Memoirs of the Department of Agriculture in India, Veterinary Series, Vol. I, No. 2. Price, Re. 1-4.	Major J. D. E. Holmes, M.A., D.Sc., I.C.V.D., Imperial Bacteriologist.	Thacker, Spink & Co., Calcutta.
90	Note on Surra. Bulletin No. 27 of the Department of Agriculture, United Provinces. Price, 6 pies.	E. W. Oliver, M.R.C.V.S., F.Z.S., Superintendent, C.V.D., United Provinces.	Government Press, United Provinces, Allahabad.
91	Anti-Rinderpest Serum. Cultivators' leaflet No. 42 of the Department of Agriculture, Burma.	Issued by the Department of Agriculture, Burma.	Government Printing, Burma, Rangoon.
92	Breeds of Indian Cattle, Bombay Presidency.	K. Hewlett, M.R.C.V.S., late Superintendent, Civil Veterinary Department, Bombay Presidency.	Government Printing, India, Calcutta.

PUBLICATIONS OF THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA.

[TO BE HAD FROM MESSRS. THACKER, SPINK & CO., CALCUTTA.]

Annual Report of the Imperial Department of Agriculture in India, for the year 1904-05. Price, As. 12 or 1s. 2d. (*Out of print.*)

Report of the Imperial Department of Agriculture in India, for the years 1905-06 and 1906-07. Price, As. 6 or 7d.

Report of the Agricultural Research Institute and College, Pusa (including Report of the Imperial Cotton Specialist), for the years 1907-09. Price, As. 4.

Report of the Agricultural Research Institute and College, Pusa (including Report of the Imperial Cotton Specialist), for the year 1909-10. Price, As. 4 or 5d.

Report of the Agricultural Research Institute and College, Pusa (including Report of the Imperial Cotton Specialist), for 1910-11. Price, As. 6 or 7d.

Report on the Agriculture Research Institute and College Pusa (including Report of the Imperial Cotton Specialist), for 1911-12. Price, As. 6 or 7d.

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